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CITY OF HELENA:
EVALUATION AND DESIGN OF SOLID WASTE RESOURCE RECOVERY FACILITY

Prepared for
MONTANA DEPARTMENT of NATURAL RESOURCES and CONSERVATION

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CITY OF HELENA: EVALUATION AND DESIGN OF SOLID WASTE RESOURCE RECOVERY FACILITY

Prepared by

Richard Frounfelker
Systech Corporation
245 North Valley Road
Xenia, Ohio 45385

Joseph Swartzbaugh
Stahly Engineering & Assoc.
1 South Dakota
Helena, MT 59601

March, 1982

Prepared for

Montana Department of Natural Resources and Conservation
32 South Ewing, Helena, Montana 59620
Renewable Energy and Conservation Program
Grant Agreement Number 311-800

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HELENA'S SOLID WASTE RESOURCE RECOVERY FACILITY
Findings and Recommendations
February 4, 1982

Having worked closely with the consultant over the past year during the evaluation and design of a solid waste resource recovery facility, the Waste-to-Energy Steering Committee respectfully offers the following findings and recommendations for consideration by the Helena City Commission and the Capitol Complex Planning Committee.

FINDINGS

1) From a technical standpoint it is possible, using technology which is available today, to build and operate a facility which would convert Helena's solid waste to energy in the form of steam and electricity.

2) The examination of various available techniques performed by the consultant appears to be adequately performed for purposes of making a decision to pursue or reject a plant at this time.

3) There has been found to be no rationale for expecting users of waste disposal services or city or state taxpayers to subsidize an uneconomic means of disposing of solid wastes.

4) The economics of a plant--either at Fort Harrison or the Capitol Complex--are so poor that we cannot advise the City to proceed with detailed design and construction in today's economy.

5) In order for the facility to be economic, major changes would have to occur in one or more of the following areas:
   a) Major increases in the price of natural gas.
   b) Major increases in the price of electricity.
   c) Substantial cost increases or unavailability (e.g. termination of BN lease) of landfill services to the City.
   d) Availability of capital improvement grant support.

6) The economic analysis by the consultant focuses primarily on operating and maintenance costs. To recover the costs of the facility at the Capitol Complex, assuming 15 years and 12 percent interest, requires \$1.18 million per year, or \$50.86 per ton--more than doubling the costs per ton. For the Fort Harrison facility, debt service comes to \$675,000, or \$36.99 per ton additional, nearly doubling costs.

7) The City should be aware that the costs of the present landfill operation will rise.

RECOMMENDATIONS

1) Accept the consultant's report and award final payment.

2) For the time being, place a "hold" on the further pursuit of a resource recovery facility.

3) The Public Works Department of the City of Helena should be directed to review and report to the City Commission, on an annual basis, the following:

a) Status of the City's lease of BN property for the current landfill.

b) Prices of natural gas and electricity to steam and electrical customers.

Commissioners
Rich D. Brown, Mayor
Michael J. DaSilva
Dale L. Johnson
James H. Nybo
Russell J. Ritter

Robert A. Erickson
City Manager

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City-County Admin. Bldg.
316 North Park
Helena, MT 59623

Phone 406/442-9920

March 12, 1982

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MONT. DEPT. of NATURAL RESOURCES & CONSERVATION

Ms. Georgia Brensdal
Renewable Energy Bureau
Department of Natural Resources
32 South Ewing
Helena, Montana 59620

RE: Grant No. RAE 311-800

Dear Ms. Brensdal:

Following is a listing of the members of the City of Helena Waste-to-Energy Steering Committee for the above referenced grant.

*Richard A. Nisbet	City of Helena - Dir. of Public Works
*Stan Sternberg	Air Quality Bureau
*Duane Robertson	Solid Waste Management Bureau Chief
Bill Potts	Solid Waste Management Bureau
*Jim Nybo	Former City Commissioner
*David Holbrook	Veterans Administration Center
*Mel Humphrey	Citizen in Proposed Study Area
*Dr. Ed Crowley	Citizen of Helena
Don Lewis	City of Helena Sanitation Supt.
Ed Robinson	City of Helena Energy Rep.
George Nolan	State Architecture & Engr. Division
Bobby Spilker	State Capitol Complex Planning Committee

The persons marked with an asterisk are the members of the original committee appointed by the City Commission.

If you need additional information, please call.

Sincerely,

JOAN M. ELLIS
Administrative Assistant
Public Works Department

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SECTION 1

INTRODUCTION, SUMMARY, AND RECOMMENDATIONS

INTRODUCTION

The State of Montana Department of Natural Resources and Conservation awarded the City of Helena a grant to evaluate the technical and economic feasibility of a solid waste-to-energy (SWTE) facility. The findings of an earlier general study on solid waste management alternatives in Helena identified the Fort Harrison Veterans Administration Hospital as a potential energy market along with the State Capitol Complex.

The proposed facilities were considered from the point of view of energy generating plants and not solid waste disposal facilities. There was no detailed analysis of the solid waste disposal methods in the area. Based on other studies, the assumption was made that the existing landfill will be suitable for the next 15 years. However, during the course of the energy analysis, it became apparent that the availability of the existing landfill site can be jeopardized due to the requirement for approval of the lease extension. Finding another landfill site within the valley area could be difficult if not impossible. The proposed incineration facility could therefore become the only practical solid waste disposal alternative. The City of Helena must give consideration to this detail when considering the costs, benefits, and risks of the facility.

A three-part approach was taken for this evaluation. Part 1 was a project overview. The tasks included in this phase were: (1) to determine amount of solid waste present and the amount of energy that can be recovered from it, (2) to verify that the Fort Harrison facility is the most viable candidate market, (3) to evaluate the potential for co-disposal of the sewage sludge with the solid waste, (4) to determine if there are any environmental constraints associated with such a facility, and (5) to identify potential technologies for recovering and delivering the energy to the customer. Phase 2 developed detailed cost estimates, including operating and maintenance costs, of specific alternatives. The advantages and disadvantages of the technologies were presented along with a preliminary system layout. In Part 3, an analysis of the institutional, legal, and financial alternatives of a specific candidate facility was completed.

SUMMARY

The following items summarize the results of the Part 1 effort:

1. The average daily amount of solid waste available for incineration varies drastically from 60 to 100 tons per landfill receiving day

from winter to summer, respectively. This variability severely complicates the design of the solid waste-to-energy facility and its operation.

2. Private individuals are currently delivering solid waste at a rate of 100 to 300 vehicle loads per day. To handle this influx of private vehicles will require expensive design features in the plant, resulting in higher labor costs. Traffic will also be a problem. The design in Part 2 should address the problem and decide if private vehicles should be allowed at the facility.

3. The energy market survey indicated that the State Capitol Complex had a higher annual energy demand than the Fort Harrison facility if a central heating loop is constructed. The majority of the energy demand at both facilities is for heating. As a result, the highest energy demand is during winter, the period of lowest solid waste availability. The peak period for electricity generation is during the summer, the period of highest waste generation. The cost of installing electrical generation and control equipment on this small scale versus revenues from the sale of electricity is high. Generation of electricity also adds problems to the management of the facility.

4. The technology for co-disposal of sewage sludge is still in the demonstration stage in the United States with no plants of the size required in Helena in routine operation. Although primary sludge has a heating value higher than digested sludge, the potential problems with odors during processing, transporting, and storage were found to be greater. It was decided that the wastewater treatment plant system should be expanded as planned to include a new primary digester and secondary digester system. If sludge disposal becomes a problem, incineration with or without energy recovery would be considered at some time in the future.

The results of the Part 2 system design and cost analysis are summarized as follows:

1. The technology to be used to recover energy from the municipal solid waste (MSW) is the modular controlled air incinerator. This technology was chosen because its capital costs are lower, current data on its operational costs are comparable to other technologies, and the energy recovery efficiency is adequate to meet the energy market demands.

2. The capacity of the system was determined to be a 100 tons per day (TPD) facility proposed for the Capitol Complex and 50 TPD for the Fort Harrison VA Hospital proposed facility. The capital costs of the 100-TPD facility was estimated to be $5,244,000 in 1981. The annual operational cost over 260 days was estimated to be $715,000 or $30.83 per ton in 1985, the expected first year of operation. The 50-TPD facility was estimated to cost $2,967,000 in 1981. The

annual operating cost over 365 days was estimated to be $714,500 or $39.15 per ton in 1985.

3. The option to generate electricity was designed into the proposed facilities layout. However, the incinerator/steam heating plant was designed to be operated first before consideration is given to the electric generation operation. This is due to the greater complexity of equipment and management controls for the sale of electricity. However, if the electric system is not built, a steam condensing system will be required in order to permit the incinerator gases to pass through the boiler during periods of low heating demand to be cooled before entering the baghouses for emissions control. An alternative wet scrubber system could be built. Either system could create a vapor plume from the required cooling towers.

4. There was not sufficient information to develop a ±10 percent cost estimate of the central heating/cooling loop and existing heating and cooling equipment conversion. The estimate can be considered at best to be ±20 percent. A study of the details of the central loop requirements and the average hourly heating/cooling demands should be initiated by the State Capitol engineers.

5. The proposed facilities can be designed to be compatible with the surrounding neighborhoods. Environmental emissions can be controlled except for a small visible vapor plume from the stack during cold weather. Noise levels will be very low due to the enclosure of all motors and equipment within the structures. Noise from the delivery trucks will be during daylight hours only, and no private cars will be permitted in order to control traffic congestion and lower capital costs.

6. To calculate revenues from the proposed facilities, two scenarios were developed over the 15-yr life of the facilities. In both scenarios, the steam was assumed to be sold at a cost equal to that of steam generation by natural gas, and the tipping fee for the solid waste was assumed equal to the landfill costs per ton.

   Revenues from the sale of energy and for disposal of solid waste were calculated at both sites. Under two scenarios the revenues were projected to increase 10 percent and then 15 percent per year. Operational costs were inflated an average of 10 percent per year. Not including debt service over the 15-yr life of the facilities, the Capitol Complex facility generated about $17 million after costs under the 15 percent inflation scenario but could only equal costs under the 10 percent scenario. The Fort Harrison facility could not generate more dollars than costs under either scenario and resulted in a net loss.

The following items summarize the results of the Phase 3, Implementation Analysis study:

1. There are several approaches available for the construction of a waste-to-energy facility. When the final site is selected and ownership decided, a selection of the method can be made. The Architectural and Engineering (A&E) approach appears to be the most feasible procurement and design method.

2. Financing of the facility can be accomplished through revenue or general obligation bond sales by the City or State or capital improvement costs by the federal government at Fort Harrison. Since the facilities are projected not to generate large cash flows, private investment such as a leveraged lease does not appear feasible.

3. Construction of the facility would take 3 to 4 years to complete. The steps involved are: (1) site selection, (2) financing approval, (3) contract negotiations, (4) Request for Proposals, (5) final design, (6) bonding, (7) construction, (8) start-up and shakedown, and (9) acceptance testing.

4. The technical risks are about equal at each site since the same equipment is proposed. Although the capital investment is higher at the State Capitol Complex, the financial risk is greater at the Fort Harrison site since the projected economics do not show sufficient revenues to retire the debt service.

   The economic success of the Capitol Complex facility is determined by the increase of the price of natural gas in Montana. The price of gas must increase at a rate greater than the inflation of labor or other costs in order for sufficient monies to be generated to retire the debt service.

RECOMMENDATIONS

SYSTECH recommends that the City of Helena:

1. Continue to study waste-to-energy facilities as a method of waste disposal. However, based on the economics presented in this study no procurement action is recommended until one or more of the following occurs: (1) problems with disposal at the existing landfill site develops, (2) natural gas prices increase at a rate greater than 15 percent, and (3) a new energy market is identified that utilizes a minimum of 75 percent of the proposed facility's annual output.

2. Apply for a grant from the State to continue evaluation of incineration with energy recovery. Within the grant the Solid Waste Advisory Committee should (1) visit regional sites

under construction or in operation (Burly, Idaho, Livingston, Montana, and other sites in Washington State); (2) study the public response to the proposed Capitol site; (3) assess the impact of the Helena landfill site's future on the program; (4) continue discussions with personnel at the State Capitol; (5) continue review of the projections for the costs of energy; and (6) monitor the operational and maintenance costs of existing facilities.

3. Select the Capitol Complex as the primary proposed location but retain the Fort Harrison site as an alternative.

4. Obtain a detailed cost estimate of constructing a central steam loop at the Capitol facility and converting all the buildings to a central cooling system.

5. Review the situation and prepare final cost estimates when the state legislature meets again in 1983.

6. Explore the potential for the State to provide a grant through the coal taxes or other sources or pay for costs of the central heating loop through their capital improvement program.

SECTION 2

SOLID WASTE VOLUMES, ENERGY MARKETS, AND CO-DISPOSAL TECHNOLOGY

SOLID WASTE AMOUNTS AND ENERGY CONTENT

The availability of solid waste and its associated energy value are factors which are applied when sizing a solid waste-to-energy facility. Because the SWTE facility is designed for a specific capacity, variations in system throughput negatively affect system efficiencies and economics. These variations in quantity can result from seasonal effects, long-term trends in waste generation rates, or short-term effects such as the "spring cleaning" surge. It is therefore critical to properly characterize the quantity of waste generated in Helena prior to beginning the preliminary design.

In addition to determining the quantity of solid waste generated in Helena, the energy value of the waste must be determined. The energy value of solid waste is based on composition in terms of processable and nonprocessable material. Processable material can be fed to the incinerator without size reduction and may or may not be combustible in nature. Residential waste and general commercial waste (paper, packaging material, etc.) is considered processable and contributes to the overall energy value. Nonprocessable material is generally inert with little or no energy value, and it is removed from the waste stream prior to incineration. Nonprocessables consist of construction/demolition debris; white goods (stoves, refrigerators, etc.); and other large bulky items. The percentages of processable and nonprocessable material were determined from previous studies on the solid waste composition of Montana. The composition data, along with the quantity determinations, allow an evaluation of the amount of energy which can be derived from the solid waste.

The solid waste quantity and energy value determinations are based upon the waste received at the Helena Sanitary Landfill. Additional waste may be available from adjacent counties, and its potential impact on the proposed facility design is also considered.

SOLID WASTE QUANTITY

Helena Sanitary Landfill

To determine the amount of solid waste available for incineration in the proposed SWTE facility, the scale weight records of the City of Helena Sanitary Landfill for the past 6 years have been reviewed. As illustrated in

Figure 2-1, the annual total amount of solid waste received at the Helena landfill has steadily increased from 22,640 tons in 1974 to 31,125 tons in 1980. Part of the increase since 1978 is due to the expanded use of the landfill. In March 1978, the City of East Helena and Hartley's Garbage Service began to use the site. They added approximately 190 and 430 tons/yr (TPY), respectively. In October 1980, the Helena landfill also began to accept solid waste collected from the northern section of Jefferson County. The rates were 100, 100, and 128 tons for the respective months of October, November, and December. The waste received from Hartley's Garbage Service is collected within an approximate 15-mile radius of the City of Helena, excluding the Scratch Gravel District.

Impact of Adjacent Counties

It is conceivable that waste which is not currently received at the Helena Sanitary Landfill may be available for incineration at the proposed Helena SWTE facility. This would include waste generated in southern Jefferson County and in Broadwater County. The solid waste generation rates in these areas must then be determined in order to assess their potential impact on the proposed facility.

Table 2-1 was developed from waste generation rates established in the "Population, Employment, and Waste Generation Report for the State of Montana Solid Waste Management and Resource Recovery Study," January 1976. These generation rates are 3.25 lb/person/day for cities with populations of 1000 to 5000 and 2.25 lb/person/day for cities with populations of less than 1000.

TABLE 2-1. IMPACT OF WASTE FROM ADJACENT COUNTIES

County	Total population	General rate (lb/person/day)	Total solid waste (tons)	Solid waste available (tons)
Jefferson	7040	3.25	4176	2976
Broadwater	3263	2.25	1340	1340

Jefferson County--

According to the 1980 census, the total population of Jefferson County is 7040. The areas of population concentration in the County generally fall into the range of 1000 to 5000 persons, which corresponds to a generation rate

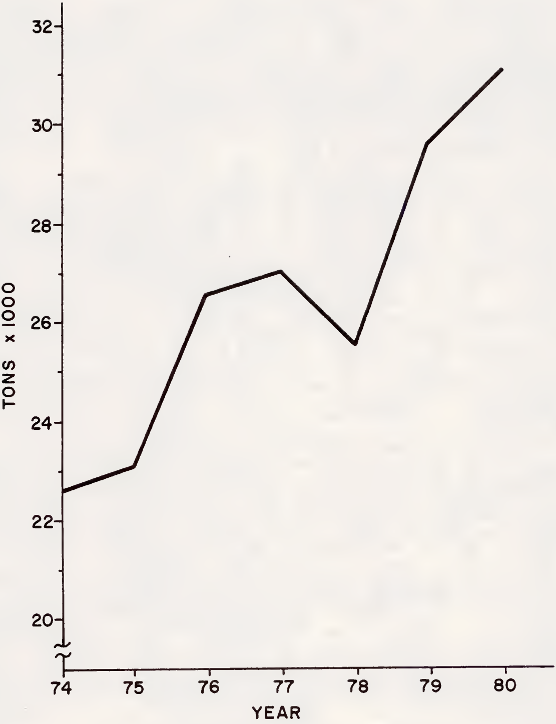


Figure 2-1. Annual solid waste received at Helena Sanitary Landfill.

of 3.25 lb/person/day. This yields an annual total of 4176 tons. Approximately 100 tons per month (TPM) are currently disposed at the Helena landfill leaving 2976 TPY still available. Based on the 1980 total waste received at the Helena landfill, this additional refuse would result in an annual increase of approximately 10 percent.

Broadwater County--

The 1980 census established the population of Broadwater County to be 3263 persons. The generation rate of 2.25 lb/person/day will be used in this determination because the areas of population concentration are generally less than 1000 persons. At this rate, the annual solid waste generation is 1340 tons. Based on the 1980 total waste received at the Helena landfill, this additional refuse would yield an annual increase of 4 percent. The combined total increase of the solid waste generated in Broadwater County and southern Jefferson County is 14 percent, or 4316 TPY.

MONTHLY GENERATION RATES

Since the proposed SWTE facility will be designed for a specific capacity, variations unaccounted for in the system throughput will negatively affect system efficiency. It has been determined that the long-term trends in generation rates are increasing at a steady rate, which is a favorable condition for the modular approach to the SWTE facility as proposed for Helena. The short-term variations, such as seasonal fluctuations and surges associated with occurrences such as "spring cleaning," must now be considered.

The monthly waste received during 1978, 1979, and 1980 is quantified in Table 2-2. Figure 2-2 is a graphic presentation of this data given as tons per landfill receiving day versus month of the year. Presenting the data on an average daily basis reduces the possibility of a month appearing to have a low monthly generation rate because it has fewer days. This does not affect the total monthly average and is the method which will be used for further evaluations.

Generally, solid waste generation increases during the spring and summer months, April to August, then starts to decrease. Seasonal variations of 20 to 30 percent are common, and surges in the spring are usually attributed to spring cleaning. However, the variations seen in Helena's waste are greater than usually encountered in other areas of the nation. Although the average monthly variation is 11 percent, variations as high as 68 percent are apparent between February (1915 tons) and July (3213 tons).

A potential cause for the extreme variations in solid waste may in part be due to the waste brought in by individual Helena residents in private vehicles. In 1979 records of private vehicles entering the landfill were maintained. The monthly totals ranged from 1601 vehicles in February to 4428 vehicles in June. The associated tonnage is plotted in Figure 2-3, along with the tonnage received from City collection and commercial haulers. The City delivers about 60 percent of the annual tonnage while the remaining 40 percent is split about equally between the private citizens and the commercial haulers. These wide monthly variations of total refuse available

TABLE 2-2. CITY OF HELENA SANITARY LANDFILL RECEIVING RATES

	1978			1979			1980		
Month	TPM*	Receiving days	Tons per receiving day†	TPM§	Receiving days	Tons per receiving day†	TPM*	Receiving days	Tons per receiving day†
Jan	1400	26	54	1776	26	68	2179	26	84
Feb	1300	23	57	1566	22	71	1915	24	80
Mar	2000	27	74	2432	27	90	2062	26	79
Apr	2325	25	93	2395	24	100	3190	26	123
May	2225	26	86	3113	26	120	3196	26	123
Jun	2050	26	79	3025	26	116	3198	24	133
Jul	1750	25	70	2494	25	100	3213	26	124
Aug	2200	27	81	2992	27	111	2677	26	103
Sep	2150	25	86	2476	24	103	2700	25	108
Oct	2050	25	82	2070	26	80	2750	26	106
Nov	2075	25	83	1881	25	75	2095	23	91
Dec	2075	27	77	1886	25	75	2005	26	77

* City of Helena landfill records.

† Figured on a 6 day/week receiving basis.

§ Data from Peccia report, 1980, Figure III-4.

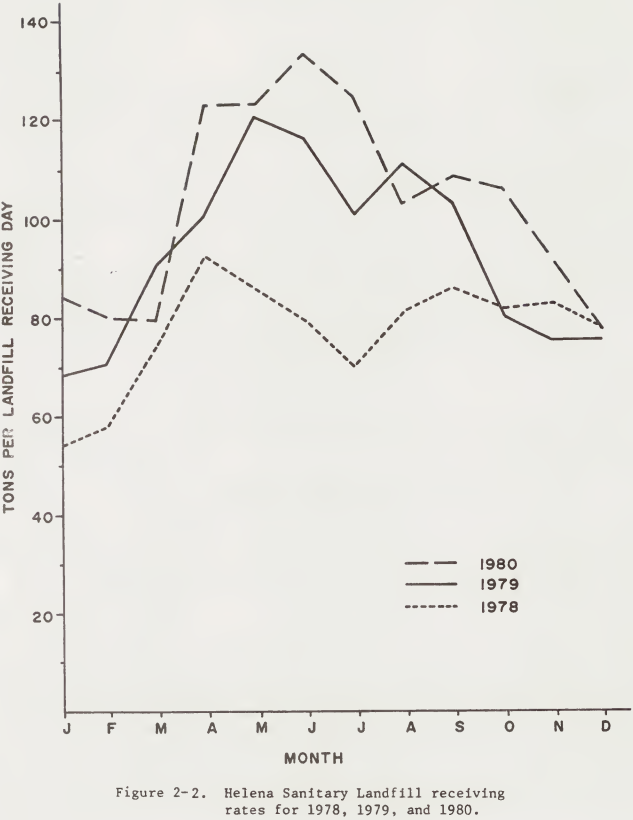


Figure 2-2. Helena Sanitary Landfill receiving rates for 1978, 1979, and 1980.

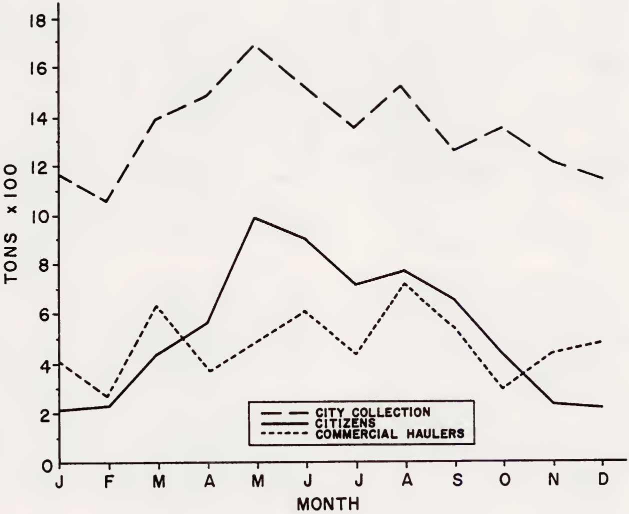


Figure 2-3. 1979 Helena Sanitary Landfill receiving rates.

for processing will pose a significant problem in the efficient sizing of the proposed SWTE facility. A further consideration will be how to accommodate the private vehicles entering the site. The logistics of handling waste delivered by up to 300 private vehicles per day (see Table 2-3) will require serious deliberation.

DETERMINATION OF PROCESSABLE QUANTITY AND ENERGY VALUE OF SOLID WASTE

Processable Quantity

Review of the Helena Sanitary Landfill weight records established that 31,180 tons of solid waste were available for the proposed SWTE facility in 1980, and it appears that an annual increase of 6 percent can be expected. The next preliminary design criteria is an evaluation of the solid waste energy value, which can be determined from the composition of the refuse. Because the main focus of this study is the feasibility of solid waste to energy, the refuse will be sorted into two categories, processable and nonprocessable. Size and energy value are the major factors for distinguishing between the two categories. Large items such as tree limbs and old furniture may have an inherent energy value, but their bulky nature is prohibitive to the feed system of the SWTE facility. Although the system may be capable of handling construction and demolition waste, its low energy value makes it undesirable. Alternatively, processable material generally has a higher overall energy value, and its size is amenable to the feed system. Processable waste is considered to be residential waste and general commercial waste (paper, packaging, etc.).

Table 2-4 presents the solid waste received at the Helena landfill from 1974 through 1980 in three waste categories: bulky, city collected, and commercial and private haulers. The bulky waste category is considered 100 percent nonprocessable. The City collected waste is assumed to be 18 percent nonprocessable. This determination is drawn from the report "Population, Employment, and Waste Generation Report for the State of Montana Solid Waste Management and Resource Recovery Study," January 1976, which indicated that for areas with populations over 10,000, such as Helena, the unprocessables account for 18 percent of the total waste stream. Based on observations made by SYSTECH personnel at the Helena landfill, the final category, commercial and private haulers will be considered 25 percent unprocessable. The total unprocessable percentage is then approximately 25 percent, which corresponds to the determination made in the "Population, Employment, and Waste Generation Report for State of Montana Solid Waste Management and Resource Recovery Study" of 18 to 25 percent. Table 2-5 presents the 1980 monthly solid waste quantities as processables and nonprocessables. The total processable tonnage was 23,200, and the total unprocessable tonnage was 7,980.

Energy Value

The processable portion of the solid waste as defined in the previous paragraph is that waste which will be utilized in the SWTE facility. The results of numerous solid waste field sampling determinations done by SYSTECH

TABLE 2-3. SOLID WASTE DELIVERED TO HELENA SANITARY LANDFILL IN PRIVATE VEHICLES, 1979

	Number of private vehicles			
Month	Monthly totals	Daily high	Daily low	Tons per month
Jan	1595	100	43	211
Feb	1601	132	20	225
Mar	2777	303	32	435
Apr	3768	387	65	541
May	4155	303	101	970
Jun	4428	261	109	897
Jul	3777	233	108	712
Aug	3828	216	93	758
Sep	3147	245	74	644
Oct	2959	216	79	432
Nov	1637	185	57	235
Dec	2071	138	36	227

TABLE 2-4. HELENA SANITARY LANDFILL RECORDS, SOLID WASTE TONNAGE

Year	Bulky	City collection	Private & commercial haulers	Total
1980	1,755	16,163	13,262	31,180
1979	1,543	16,154	11,932	29,629
1978	732	13,550	11,359	25,641
1977	1,349	12,886	12,878	27,113
1976	1,525	13,260	11,868	26,653
1975	1,173	13,159	8,758	23,090
1974	1,519	13,058	8,063	22,640

TABLE 2-5. TONS PER MONTH AND CHARACTERISTICS OF SOLID WASTE RECEIVED AT HELENA SANITARY LANDFILL IN 1980

Date	Bulky	City collection	Private/ commercial	Total	Processable	Nonprocessable
Jan 31	169	1,267	743	2,179	1,596	583
Feb 28	137	1,121	657	1,915	1,412	503
Mar 31	77	1,118	867	2,062	1,567	495
Apr 30	174	1,588	1,428	3,190	2,373	817
May 31	145	1,623	1,428	3,196	2,402	794
Jun 30	209	1,550	1,439	3,198	2,350	848
Jul 31	157	1,513	1,543	3,213	2,398	815
Aug 31	133	1,300	1,244	2,677	1,999	678
Sep 30	155	1,336	1,209	2,700	2,003	697
Oct 31	147	1,408	1,195	2,750	2,051	699
Nov 30	121	1,120	854	2,095	1,558	537
Dec 31	131	1,219	655	2,005	1,491	514
Total	1,755	16,163	13,262	31,180	23,200	7,980

were used to establish the higher heating value (HHV) of processable refuse at 4500 Btu/lb. The HHV is based on the as-received characteristics of the solid waste and is its gross heat value. It compares favorably with the Environmental Protection Agency (EPA) national average of 4675 Btu/lb but is somewhat lower than the average of 5039 Btu/lb as determined in the "Population, Employment, and Waste Generation" report which was not used because it does not appear to be consistent with the composition and moisture values reported in the study. The study presents moisture values ranging from 71 to 12 percent with an average of 35 percent. The paper component weight percent was similar at the four sampling locations and averaged 25 percent. These moisture and composition numbers tend to indicate an HHV lower than the 5000 Btu/lb used in the above report. Therefore, the most conservative HHV of 4500 Btu/lb will be used for study calculations although the actual may be 10 percent above this.

Figure 2-4 plots the solid waste energy input and the energy output in the form of steam. For a modular solid waste facility generating energy as steam, a system efficiency (output) of 55 percent is considered typical. Losses are accounted for in the energy remaining in the residue, in heat lost by radiation and convection, and in sensible heat in the stack gases. During the 5-month period of November to March, an average of 7,500 million Btu (MMBtu) of usable energy can be produced. From April through July, an average of 11,800 MMBtu is produced. During August and September, an average of 9,900 MMBtu can be produced.

SUMMARY

In 1980, 31,180 tons of solid waste were received at the City of Helena Sanitary Landfill. Over the past 6 years, the Helena landfill has increased its intake of solid waste an average of 6 percent annually. Based on the available data, there is a 90 percent probability that the increase will continue.

The cumulative impact of receiving all the waste from Jefferson and Broadwater Counties is an additional 14 percent based on 1980 landfill and census data. This would result in an increase of the average rate to 97 TPD, 365 days/yr.

The quantity of waste received at the Helena landfill shows strong monthly variations. The average variation is 11 percent, but a seasonal variation of 40 percent exists between the summer and winter months with the largest difference occurring between February and July (68 percent).

Of the currently available 31,180 TPY of waste, processable waste constitutes 75 percent, resulting in 23,385 TPY being available for incineration in a SWTE facility. The estimated HHV of this refuse is 4,500 Btu/lb, providing an average yearly energy input of 210,400 MMBtu. Taking into account an incineration/steam generating system efficiency of 55 percent, the available energy output from the waste is about 115,000 MMBtu/yr.

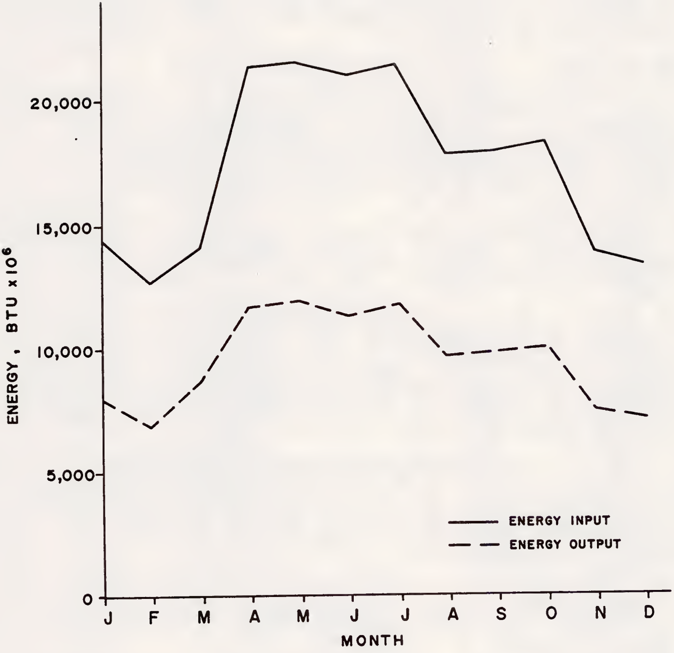


Figure 2-4. Energy available from the solid waste and energy output from a resource recovery facility operating at 55 percent efficiency.

ENVIRONMENTAL CONSIDERATIONS

Introduction

An incineration facility of the type under consideration emits various effluents consisting of air emissions, process water discharges, and solid residue. This section discusses the potential effects of these effluents on the environment and the pertinent state and federal regulations which would apply to the proposed facility. Based on data obtained from facilities in operation, the expected pollution levels and the significance of these levels are also presented.

Air Pollutants

Both particulate and gaseous emissions result from the combustion of municipal solid waste (MSW). The gaseous emissions include the oxides of sulfur and nitrogen, carbon monoxide, and unburned hydrocarbons. Due to plastics in the waste, the flue gas of a waste burning incinerator also contains chlorine. The particulate emissions consist of noncombustible ash which has been entrained in the hot gases exiting the combustion chamber.

Particulate Emissions--

Energy recovery systems are being installed and operated with and without air emissions control equipment. Those without the control equipment are generally designed to operate under "starved air" conditions with minimal agitation in the primary chamber.

SYSTECH evaluated a small modular incinerator system in North Little Rock, Arkansas, which burned municipal solid waste without emission controls. During evaluation, the particulate emission rate was 0.13 gr/dry standard cubic feet (DSCF) or 3 lb/ton of refuse charged. A summary of measured emissions rates of various other modular systems operating without emission control systems is given in Table 2-6. On the basis of the emission rate of 3 lb/ton of refuse, a system in the range of 100 TPD operating 365 days/yr would emit approximately 55 TPY of particulates.

Energy recovery systems with integrated emission control equipment include other modular type incinerators and conventional refractory-lined and waterwall incinerators. Emission control equipment is included because these technologies are based on excess air combustion which, along with increased turbulence in the primary chamber, produce higher particulate emissions. Table 2-7 shows a summary of the particulate emission levels of various systems using emission control equipment.

Gaseous Emissions--

When compared with the gaseous emissions of coal burning facilities, those emissions of waste burning incinerators have low concentrations of the oxides of sulfur (SO_x) and nitrogen (NO_x), carbon monoxide (CO), and unburned hydrocarbons (HC). The low SO_x concentrations are due to the low

TABLE 2-6. SUMMARY OF EMISSIONS TEST DATA ON SMALL MODULAR MUNICIPAL INCINERATORS

		gr/DSCF					
City	Date tested	Particulates @ 12 percent CO_2	SO_2	NO_x	HC	CO	Cl
Salem, VA*†§	3/06/79	0.105					
	6/15/79	0.124					
	11/06/79	--	0.0410	1.37×10^{-3}			
	11/07/79	--	0.0672	7.56×10^{-4}			
Tahlequah, OK*‡	9/24/79	0.108					
Mededith, NH*‡	6/08/77	0.163					
Pahokee, FL*‡	5/13/75	0.0763					
Orlando, FL*‡	5/14/75	0.0882					
Siloam Springs, AR*‡	10/03/75	0.0654					
North Little Rock, AR*†	3/21/78	0.143			7.0×10^{-5}	--	0.1506
	5/22/78	0.1906			5.2×10^{-5}	0.0154	0.0114
	10/09/78	0.1297			7.8×10^{-4}	0.0094	0.0676

* Data for this table came from a report by Acurex Corp., Research Triangle Park, North Carolina, for the U.S. EPA in 1979.

† Continuously operated units with continuous ash removal.

§ Emission Test Report, City of Salem, Salem, Virginia, Monsanto Research Corporation, February 1980.

‡ Batch-fed units without continuous ash removal.

TABLE 2-7. SUMMARY OF EMISSIONS TEST DATA ON LARGE MUNICIPAL INCINERATORS

City	System	Capacity	Control system	Date tested	Test results gr/DSCF @ 12 percent CO_2
E. Bridgewater, MA	WW	150	FF	1975	0.024
Saugus, MA	WW	600	ESP	1976	0.049
Nashville, TN	WW	360	ESP	1976	0.018
Norfolk, VA	WW	280	ESP	1976	0.05
Ogden-3, UT	MGCA	150	ESP	1974	0.045
Chicago, NW, IL	WW	400	ESP	71/75	.030/.050
Baltimore, No. 4, MD	MGCA	300	ESP	1976	0.025
Baltimore Pyrolysis, MD	RK	600	ESP	1979	0.021
Louisville, KY	RK	200	VS	1976	0.05/0.06
Sheboygan Falls, WI	CA	30-90	S	1976	0.416

Note: Source of data was the Federal Register, Volume 44, No. 229, Tuesday, November 27, 1979, page 67438.

WW = Waterwalled incinerator
MGCA = Moving grate controlled air incinerator
RK = Rotary kiln incinerator
CA = Stationary floor, controlled air incinerator
VS = Venturi scrubber
S = Low energy scrubber
ESP = Electrostatic precipitator
FF = Fabric filter

sulfur content (0.07 percent, dry basis) of the fuel. The low NO_x levels result from the generally low combustion chamber temperatures. The low CO and HC levels result from the higher volatility of the fuel and sufficient excess air to completely combust the CO and the HC. Because of the presence of plastics in the waste, the flue gas of the waste burning incinerator contains chlorine. However, there are no restrictions on the chlorine emission level because the relationship between any environmental effects and emission levels of chlorine has not been determined.

The annual gaseous pollutant emission rates from an incinerator without emission controls can be calculated assuming the following theoretical combustion conditions. A small modular incinerator produces approximately 9,900 DSCF of flue gas per ton of refuse charged. These systems normally operate at 100 percent excess air for a total of 117,000 DSCF/ton. With an annual charging rate of 36,500 tons and average values of the pollutant emission data presented in Table 2-6, the proposed facility would emit approximately 16 TPY of SO_2, 0.3 TPY of NO_x, 4 TPY of CO, and 0.1 TPY of HC.

Water Pollutants

Since some of the process water in a resource recovery facility may contact the raw wastes, this water can become a pollution source. The process waters include those used for the ash quench; the tipping floor; the equipment cleaning; and, where applicable, the wet flue gas scrubber operation. If any of these waters are discharged from the facility as wastewater, they must meet the standards required for their disposal.

In Helena the two principal wastewater depositories are the "waters of the United States," as defined in the Clean Water Act, and the municipal sanitary sewer system. If wastewater is discharged to the waters of the United States, it must be pretreated to meet the standards given in Public Law 92-500, which states "... it is the national goal that the discharge of pollutants into navigable waters be eliminated by 1985." These standards are so demanding that the cost of on-site treatment would be prohibitive compared with the cost of routing the water to the sewer system. If the wastewater is discharged to the municipal sanitary sewer system, the facility must apply for an industrial waste treatment permit. The application requires submitting the wastewater for chemical analyses to determine the pollutant components. If analyses reveal a pollutant content that exceeds the standard limits, the wastewater must be pretreated, and/or a surcharge will be assessed. The following paragraphs briefly discuss ash quench, equipment cleaning, tipping floor cleaning, and flue gas scrubber waters.

Ash Quench Water--

Most incineration systems with continuous ash removal use water to cool the ash and to provide an air seal for the incinerator. This water is generally recirculated, so it acquires a high pH and a high total solids count. Water lost in ash removal and through evaporation is replaced using fresh makeup water. Normally this quench water is discharged only when the quench pit must be drained for maintenance.

Cleaning Water--

Water used to clean the tipping floor and material handling equipment generally has high BOD, COD, and total coliform levels. This water can be easily treated by a municipal or similar wastewater treatment system.

Scrubber Water--

Water used as a scrubbing medium in a venturi or similar type wet scrubber must be pretreated before its discharge since it has a low pH, a high solids content, and is very corrosive. Even with treatment, a constant overflow of scrubber water is maintained to control the dissolved solids (including salts) unless the scrubbing system is constructed entirely of corrosion resistant materials. When conditioned, the overflow water can be easily treated in a municipal wastewater treatment plant or can be used as makeup water in the quench pit.

Solid Residue

Incineration reduces the original waste weight by about 75 percent. However, most incineration systems employ a wet ash removal system such that an equal amount of water is removed with the solid residue. Consequently, an overall net weight reduction of about 50 percent and a volume reduction of 90 percent are achieved, substantially reducing landfill costs.

When the residue is landfilled, it has the same potential as other wastes for contaminating groundwater supplies. Consequently, the EPA has classified waste incinerator residue as a "special" waste, and Montana has been developing new standards for its disposal. Under criteria proposed by the EPA, this residue will be classified as a hazardous material whenever a standard leaching test produces a leachate whose containment level is more than 10 times that allowed for drinking water.

The residue from an incinerator burning municipal solid waste is a concentration of the noncombustible fraction of the waste stream with possibly some unburned organics. It contains approximately 50 percent glass, 35 percent ferrous metals, 1 percent nonferrous metals, and 14 percent other inert materials. These percentages are based on the analysis of the noncombustible fraction of a typical as-received waste stream. Detailed laboratory analyses have revealed high (in excess of 0.1 percent) concentrations of sulfur, potassium, phosphorus, chromium, iron, zinc, tin, lead, and cadmium. Particularly significant are the chromium, zinc, tin, lead, and cadmium concentrations, since these elements are heavy metals which can accumulate in human tissue.

SYSTECH's studies of refuse incinerators and energy recovery plants have revealed that the residue normally has a sufficiently high pH to minimize heavy metal leaching. However, if the residue is disposed in an acidic environment, heavy metal leaching may become extensive. If the residue contains a high percentage of unburned organic material or if it is co-disposed with some organic waste, biodegradation of those organics will result in production of organic acids. This would result in a lower pH level for the waste and a concomitant leaching of metals.

Applicable Environmental Regulations

Unlike the federal regulations, the State of Montana Air Quality Rules establish allowable particulate emission levels for incinerators of 0.1 gr/DSCF at 12 percent CO_2 regardless of facility size. However, federal standards specify 0.08 gr/DSCF at 12 percent CO_2 and thus take precedence if the emission source has a charging rate in excess of 50 TPD. The emission source is defined as each stack associated with the facility.

Particulate--

Incinerator Standards--The proposed SWTE facility would have a charging rate of approximately 100 TPD. This charging rate could be achieved by using two 50-TPD modules. Each module could consist of two 25-TPD incinerators combined with one boiler and stack or one 50-TPD incinerator, boiler, and stack. This combination exempts the facility from the federal standards because each stack is not in excess of the 50-TPD charging rate. The State of Montana Air Quality Rules of 1980, Paragraph 16.8.1406 are applicable, resulting in an allowable particulate emission rate of 0.10 gr/DSCF at 12 percent CO_2.

If the charging rate exceeds 50 TPD at each stack, the federal air emission regulation is applicable. Under Title 40, Code of Federal Regulations, Part 60, Subpart E, the allowable emission rate is 0.08 gr/DSCF at 12 percent CO_2.

Based on the average emission rate for continuous feed units of 0.13 gr/DSCF (see Table 2-6), emission control equipment would be required to meet either the federal (0.08 gr/DSCF) or the State (0.10 gr/DSCF) particulate emission standards. Employing control equipment such as a wet scrubber, fabric filter, or electrostatic precipitator, the required emission rate would be attainable (see Table 2-7).

Gaseous--

Currently, there are no regulations concerning gaseous emissions for systems operating at less than 50 TPD. There is an established standard of 250 TPY each for SO_x, NO_x, HC, and CO under Title 40, Code of Federal Regulations, Parts 60 and 61 for systems greater than 50 TPD but less than 250 TPD. Theoretical calculations of the actual yield that would occur from a 100-TPD system are 16, 0.3, 4, and 0.1 TPY of SO_2, NO_x, CO, and HC, respectively. These calculations were based on theoretical combustion conditions of 117,000 DSCF of flue gas, an annual charging rate of 36,500 tons, and emission levels as presented in Table 2-6. These quantities fall well below the established standards and should not pose a problem.

Solid Residue--

Incinerator residue and ash collected in the air emissions control device are classified as Group I wastes under Section 16-2.14(8)-S14315. This classification stipulates that the residue be disposed in a licensed Class I disposal site. This requirement can be changed to a Class II disposal site if the residue is determined not to be hazardous by the approved EPA test procedures. Recent tests by SYSTECH on residue from various incinerator facilities have found the waste not to be hazardous. The City of Helena Sanitary Landfill is a licensed Class II site and, therefore, should be able to meet the residue disposal requirements.

Permits

Air--

Two permits are required for sources of air pollution such as the proposed waste-to-energy system. These are the Federal Prevention of Significant Deterioration (PSD) under Title 40, Code of Federal Regulations, Part 60, and the State of Montana Permit for Construction and Operation of Air Contaminant Sources under Subchapter 11 of the State of Montana Air Quality Rules, 1980.

The Federal PSD permit is required if the facility (1) has a charging rate greater than 250 TPD or (2) has the potential to emit more than 250 TPY of any regulated air contaminant. Since the proposed facility would have a maximum charging rate no greater than 120 TPD, yielding particulate emissions of approximately 70 TPY (based on Table 2-6 data), the PSD permit would not be required.

According to the specifications in Paragraph 16.8.1102 of the State of Montana Air Quality Rules, a permit for the construction and operation of an air contaminant source is required. This permit must be submitted 180 days before construction begins. The permit authorizes construction and operation of the source as defined in the permit application and the requirements of Subchapter 11 of the August 1980, State of Montana Air Quality Rules. Before construction is scheduled to end, certification that the new source has been constructed in compliance with the air quality permit is required.

Solid Waste Management Facility--

A license is required for the operation of a solid waste management system which is defined in Section 16-2.14(8)S14315, Paragraph (1)(j) of the Administrative Rules of Montana as "a system which controls the storage, treatment, recycling, recovery, or disposal of solid waste." Since the proposed waste-to-energy facility meets this description, a license to operate is required. The application is attainable through the Montana Department of Health and Environmental Sciences. Information required for the license, which must be obtained prior to establishment of the facility, is listed in Paragraph 3(a)(i) of the same section.

Other Permits--

As erection of the facility begins, general local construction permits will be required. Obtaining these permits would be the responsibility of the general contractor.

Summary

The proposed SWTE facility will emit pollutants in the form of gaseous and particulate emissions, solid residue, and wastewater. The gaseous emissions of SO_2, NO_x, CO, and HC have been calculated to be 16, 0.3, 4, and 0.1 TPY, respectively, which fall well below the established standards. At a charging rate of approximately 100 TPD, particulate emissions are expected to be in the range of 55 TPY. At the same charging rate, approximately 50 TPD of solid residue will require disposal in a licensed Class II disposal site. The City of Helena Sanitary Landfill is licensed, and disposal requirements can be met. The wastewater from the facility will require some treatment prior to discharge to the sewer system.

If the facility is sized with a charging rate of 50 TPD or less at each stack, the State of Montana emission level of 0.1 gr/DSCF will be applicable. If each stack exceeds the 50-TPD charging rate, the federal standard of 0.08 gr/DSCF will apply. Based on documented emission rates of SWTE facilities similar to that which is proposed for Helena, air pollution control equipment will be required at either charging rate.

One permit and one license will be required prior to construction of the proposed SWTE facility. These are (1) the permit for construction and operation of an air contaminant source and (2) the license for operating a solid waste management facility. After construction begins, the building contractor will be responsible for obtaining the local construction permits.

ENERGY MARKET SURVEY

Introduction

The following criteria should be met in order to provide the ideal energy market for energy derived from waste:

- Demand throughout the year in excess of the maximum output of the system.
- A location which is easily accessible without arousing public discord.
- Available land for siting the facility.
- Current energy usage in the form of steam or electricity.

A survey of the industrial, institutional, and commercial energy users in Helena revealed that no one customer could meet all the above listed criteria. Several did meet one or more though, and it is on this basis that further investigation of the customer was initiated. Table 2-8 is a list of the potential energy customers and which criteria they meet.

TABLE 2-8. POTENTIAL ENERGY USERS

	Capitol Complex	Fort Harrison	Industrial park	Sewage treatment plant	Montana Power Company
Excess demand					X
Favorable location		X	X	X	X
Available land	X	X	X	X	X
Compatible existing system*	X	X		X	X

* As steam or electricity.

The energy value of a fuel may be expressed as either input or output energy. Input energy is the total energy value of the fuel as it enters the boiler system. The output energy accounts for losses due to boiler efficiency and represents the usable or replacement energy value. Steam producing SWTE facilities typically are 55 percent efficient, and natural gas fired boilers are typically 80 percent efficient. Calculations of customer demand versus availability are based on output energy values. Economics will be based on input values of the replaced fuel.

Helena Industrial Site

The Helena industrial site was chosen for further investigation as a potential energy customer because industrial zoned land is available for siting the facility. The location is such that transportation of the solid waste to the facility would not create adverse reactions from the general public nor cause excessive transportation costs.

The new industrial park is located within the city limits of Helena, approximately 2 mi from the city center. There are several industries located there with several small lots still available. Individual heating and cooling systems are utilized by the park residents. Although several of the buildings are fairly large, they are generally used as warehouses and require minimal heating and cooling. Table 2-9 lists the commercial establishments currently located at the industrial site and their energy consumption given in thousand cubic feet (MCF) of natural gas. Of the 13 companies, 9 currently use natural gas for heating, and 7 of those supplied information on their consumption. To estimate the feasibility of interconnecting the various consumers to a central waste-to-energy facility, the range of consumption versus solid waste energy available is plotted in Figure 2-5. Since consumption information was given as seasonal usage, the graph was developed as industrial site consumption during January through

TABLE 2-9. HELENA INDUSTRIAL SITE

Company	Building size (ft^2)	Energy type	Consumption
Nabisco	23,000	Gas	273 MCF, Dec 1980 2.9 MCF, Jul 1980
Helena News	3,000	Wood, fuel oil	NA NA
Dougs Auto Body	2,000	Electric	NA
Foley Cabinets	9,600	Gas	158.4 MCF, Jan 1980 1.9 MCF, Aug 1980
Big Sky Water	1,800	Gas, electric	NA NA
Treasure Chemical Company	NA	NA	NA
Dans Glass	6,000	Gas	73.6 MCF, Dec 1980 7.8 MCF, Jul 1980
Coca Cola	10,000	Gas	$1,000 Winter $200 to $300 Summer
Western Laboratories	2,500	Gas	488 MCF, Dec 1979 84 MCF, Aug 1980
Westech	4,000	Electric	NA
Hill Construction	NA	Gas	58.1 MCF, Jan 1979 2.0 MCF, Aug 1980
McLee Sheet Metal	6,000	Gas	NA
City Shop	16,000	Gas	422 MCF, Jan 1980 9 MCF, Jul 1980

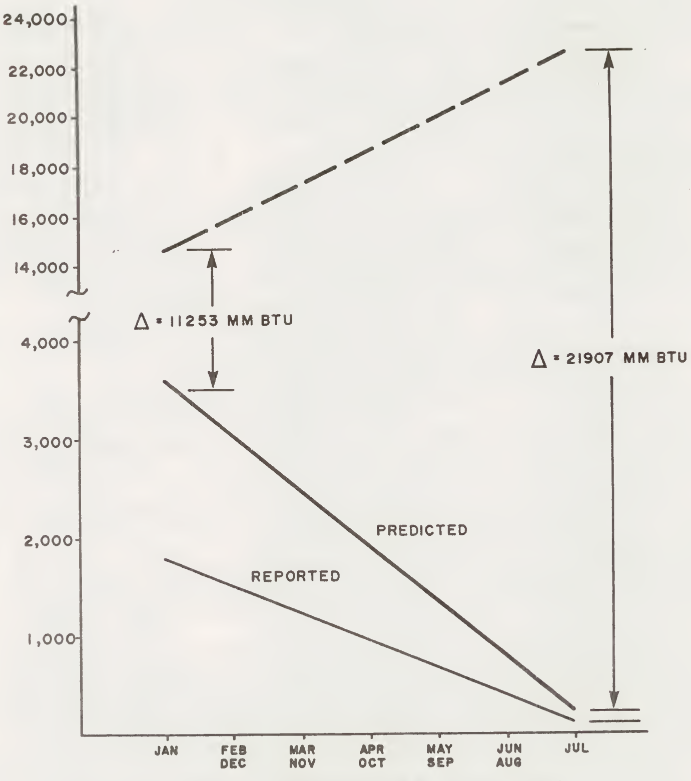


Figure 2-5. Energy demand at the industrial park vs available energy from the solid waste facility.

December and July through August versus solid waste energy available as steam during December through January and July through August. In both cases we have assumed a straight-line increase or decrease between winter (January through December) and summer (July through August). This shows an order of magnitude difference of ~10 between winter demand versus availability and an order of magnitude difference of ~100 between summer demand versus availability. These figures reflect only half of the energy consumers at the site. If we assume the other half to have similar demands, thereby doubling the demand (see Figure 2-5), it shows a usage of 24 percent during the winter and a usage of only 2 percent during the summer.

The low energy usage rate, combined with the expense of installing a central steam distribution system, creates an unfavorable economic condition and therefore eliminates the industrial park in its current status as a potential energy market. An alternative is to develop a new industrial park, near the existing one, around the incineration/heat recovery system. The incinerator/heat recovery system could attract industries by providing energy at a price below the market price of other fuels. Such a potential customer is the Hill Construction Company. They currently have a building in the park but have expressed interest in starting a prestressing concrete operation. To do so would require more space than that available at their present site. Other existing industries might also be interested in relocating to the new park.

Such an energy park would provide the potential for new employment in the area but would be more expensive than the current fuels and solid waste disposal alternatives until the energy market exceeds 75 percent of the capacity of the plant. Creation of the system would have to coincide with an intensive search for new energy customers. The energy available for sale during each month of the year is shown in Figure 2-4.

Capitol Complex

As a potential energy market for the proposed Helena SWTE facility, the Capitol Complex has several positive aspects. A central steam heating network is currently used for several buildings, and the others utilize individual hot water boilers, therefore eliminating the need for a heat system conversion. Land is also available within the complex for siting the facility. The major drawback is location. It may be very difficult to gain public acceptance for siting a waste-to-energy facility in the center of the City. Transportation of the solid waste may also be difficult because of the relatively high level of traffic and general activity associated with the Capitol Complex.

The Montana State Capitol Complex is located approximately 1 mi from the geographic center of Helena and covers a four square block area. The majority of the smaller buildings have their own boiler systems to provide heat and hot water. There is a central boiler plant, however, which serves the following large buildings: Capitol, Livestock, Budget Program Planning, and the Board of Health. The Mitchell Building can also be heated by the central plant in an emergency. A new building is under construction, and additional buildings are currently in the planning stage. They will be located on land which is available in the immediate area.

Based on the average of the 1978 and 1979 energy consumption data, the total annual input energy is 64,004 MMBtu per year. This is the total energy currently supplied to the central boiler system and the individual systems for the SRS Building and the Fish and Game Building at an average annual rate of 54,667; 7,248; and 2,092 MMBtu, respectively. Assuming a natural gas fired boiler efficiency of 80 percent, the total replaceable energy demand is 51,203 MMBtu per year. The additional building, currently under construction, has been estimated to raise the annual replaceable energy demand to 58,913 MMBtu.

Table 2-10 presents the replaceable energy demand at the Montana State Capitol Complex versus the available solid waste energy. The highest demand occurs during the months of December through March. During these months, 100, 100, 100, and 80 percent, respectively, of the available solid waste energy would be consumed. In January and February the demand exceeds the availability of solid waste energy, and a supplemental energy supply would be required. The months of June, July, August, and September have the lowest energy demand. These months correspond with the highest solid waste energy availability. Therefore, during these months, only 16, 5, 6, and 12 percent, respectively, of the solid waste energy available would be consumed. Based on the entire year, the total solid waste energy available as steam is 114,830 MMBtu versus the existing replaceable energy demand of 51,203 MMBtu, for an annual available energy usage of 42 percent. The replaceable energy demand, including the building under construction, would follow similar demand/usage trends. Overall, the total replaceable demand of 58,913 MMBtu is equivalent to 46 percent of the available solid waste energy. Figure 2-6 is a graphic representation of the demand versus availability at the Capitol Complex.

Overall, the Capitol Complex is a favorable energy market. The existing central steam system and the availability of land would make siting and steam tie-in relatively easy. Inclusion of the new building, the SRS Building, and the Fish and Game Building would require a minimal amount of additional steam lines. Public opposition, if as strong as anticipated, could eliminate this potential market.

Fort Harrison Complex

As a potential energy market, the Fort Harrison complex has the favorable attributes of a compatible central steam system and available land. Its geographic location is such that transportation of the solid waste should not meet with strong opposition. For these reasons, the current energy demand at Fort Harrison versus the steam energy produced from the proposed SWTE facility is evaluated.

The Fort Harrison complex, which serves as a Veterans' Administration Hospital, is located approximately 4 mi west of the City of Helena. The

TABLE 2-10. CAPITOL COMPLEX: ENERGY DEMAND VS AVAILABLE SOLID WASTE ENERGY

Month	MSW* output Btu × 10^6	Existing consumption Btu × 10^6	Balance† ± Btu × 10^6	Usage percent	New building Btu × 10^6	Balance† ± Btu × 10^6	Usage percent
Jan	7,900	9,404	− 1,502	100	10,842	− 2,942	100
Feb	6,989	8,082	− 1,093	100	9,295	− 2,306	100
Mar	7,756	6,210	+ 1,546	80	7,141	+ 615	92
Apr	11,746	4,864	+ 6,822	41	5,594	+ 6,152	48
May	11,889	3,495	+ 8,994	29	4,019	+ 7,870	34
Jun	11,630	1,904	+ 9,726	16	2,190	+ 9,440	19
Jul	11,870	645	+ 11,225	5	742	+ 11,128	6
Aug	9,895	694	+ 9,301	6	798	+ 9,097	7
Sep	9,915	1,194	+ 8,721	12	1,373	+ 8,542	14
Oct	10,150	2,275	+ 7,875	22	2,616	+ 7,534	26
Nov	7,710	4,974	+ 2,736	49	5,721	+ 1,989	74
Dec	7,380	7,564	− 184	100	8,697	− 1,317	100
Total	114,830	51,203	+ 56,946	42	58,913	+ 62,367	46

* Processable tonnage per month at 55 percent steam production efficiency.

† Existing consumption compared to MSW output.

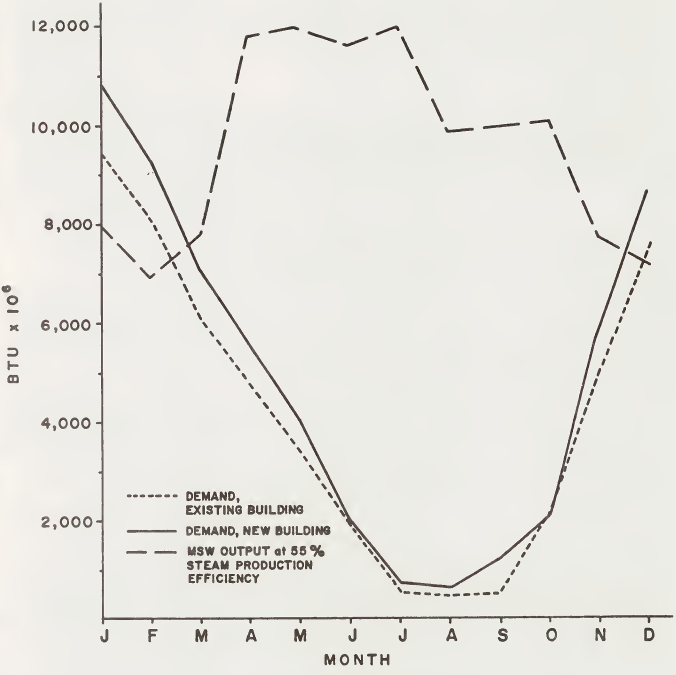


Figure 2-6. Capitol Complex energy demand vs energy availability from solid waste.

facility has a central steam system made up of three natural gas fired boilers to provide the necessary steam loads throughout the complex.

Based on 1980 steam demand records, the annual consumption was equivalent to 38,315 MMBtu. Table 2-11 presents the Fort Harrison energy demand versus the solid waste energy available. The months of November through March show the highest energy demand, the monthly range being 3,694 to 5,523 MMBtu. During these months, 49 to 70 percent of the available solid waste energy could be utilized. The summer months of June, July, and August show the lowest demand; namely, 1,906; 2,001; and 1,992 MMBtu, respectively. During these months, only 16, 17, and 20 percent of the available solid waste energy could be utilized. Over the entire year, the replaceable demand of 38,315 MMBtu versus the available solid waste energy of 114,830 MMBtu results in an annual usage of 33 percent. Figure 2-7 graphically presents the MSW energy output versus the Fort Harrison energy demand. There are no months where the demand exceeds the solid waste energy available.

The low annual usage rate of 33 percent of the steam which could be produced reduces the potential for Fort Harrison as a potential energy consumer. However, the possibility of generating electricity to sell to the local power company when the steam demand is low may increase the potential at Fort Harrison. This aspect will be explained later in this section.

Sewage Treatment Plant (STP)

The sewage treatment plant is a potential candidate market for electricity and steam if the co-disposal alternative is selected. Location of the incineration facility at the site would result in capital cost savings through the elimination of sludge handling, storage, and transporting to an off-site MSW facility and annual cost savings due to lower operational costs of the on-site sludge system. In addition, the potential aesthetic problem of noise, odor, and traffic associated with transporting the sludge would be eliminated. The refuse would be burned to produce steam to be utilized to dry the sludge. The dried sludge would then be burned along with the refuse in a co-disposal operation.

The co-disposal facility would utilize a condensing turbine to produce as much electricity as possible from the steam not required for drying the sludge. The electric demands of the wastewater plant and the co-disposal plant will be met while the excess will be sold into the public utility grid. Further design of both the municipal solid waste and the sewage treatment plants will have to be completed before the demand can be developed.

Electricity Generation

If 400-psi steam is produced at the SWTE facility, it can be utilized in a steam turbine electrical generating system. A facility in the range of 100 TPD can produce approximately 20,000 lb of steam per hour. With a small multistage condensing turbine electrical generator system, 1,200 kW can be produced from the steam. This electricity could then be sold into the Montana Power Company distribution grid under regulations set forth in Section 201 of the Public Utility Regulatory Policies Act of 1978 (PURPA).

TABLE 2-11. FORT HARRISON: ENERGY DEMAND VS AVAILABLE SOLID WASTE ENERGY

Month	MSW* output Btu × 10^6	Energy consumption Btu × 10^6	Balance† ± Btu × 10^6	Usage percent
Jan	7,900	5,523	+ 2,377	70
Feb	6,989	3,694	+ 3,295	53
Mar	7,756	4,306	+ 3,450	56
Apr	11,746	3,091	+ 8,655	26
May	11,889	2,898	+ 8,991	24
Jun	11,630	1,906	+ 9,724	16
Jul	11,870	2,001	+ 9,869	17
Aug	9,895	1,992	+ 7,903	20
Sep	9,915	2,448	+ 7,467	25
Oct	10,150	2,628	+ 7,522	26
Nov	7,710	3,807	+ 3,903	49
Dec	7,380	4,012	+ 3,368	54
Total	114,830	38,306	+ 76,524	33

* Processable tonnage at 55 percent steam production efficiency.

† Consumption compared to available.

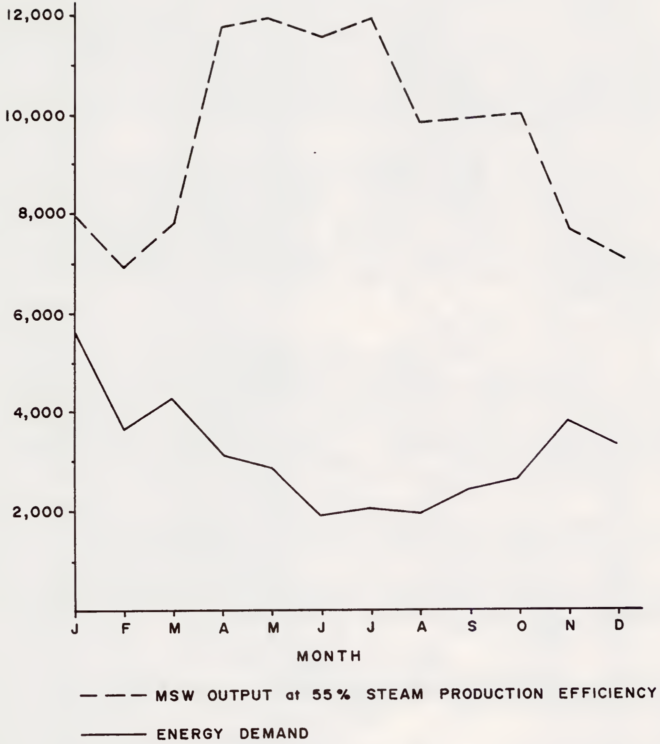


Figure 2- 7. Fort Harrison energy demand vs energy availability from solid waste.

The high capital investment required for the generating and distribution systems makes production of electricity alone economically unattractive for a SWTE facility in the range of 100 TPD. The revenue from the sale of energy as steam is much more attractive. However, since no customer has been identified as a potential buyer of all the steam produced at the SWTE facility, two alternatives for co-generation of electricity and steam will be considered.

This first alternative removes and sells some of the high pressure steam prior to the condensing turbine. This plan could be utilized at the Fort Harrison site. After their steam demand is met, the excess steam could be fed into the condensing turbine to generate electricity. Operation of the turbine requires a specified minimum steam load based on the turbine size. This minimum amount should be equivalent to the usable steam remaining after the maximum winter heating demand is met. This criteria allows year-round electrical generation. During the summer, when heating demand is low, there will be excess steam even after electrical generation because the range of minimum and maximum steam load on the turbine is small.

The second alternative involves the use of a noncondensing turbine and the sale of the low pressure exhaust steam. This low pressure exhaust steam can be used to meet the energy demand as presented for the Capitol Complex. Unlike the condensing turbine, low pressure steam with a usable energy value is exhausted from the noncondensing turbine. However, compared with the condensing turbine, the noncondensing turbine can only produce about 50 percent of the electricity per pound of steam input. Sizing of the noncondensing turbine is based on the same requirements of minimum and maximum steam load.

CO-DISPOSAL TECHNOLOGY

Thermal co-disposal is a term used to describe the incineration of MSW with sewage sludge in a common combustion system. The objective of the integrated process is to utilize the energy available from the incineration of the solid waste to evaporate the water from the sludge to a point where the sludge is dry enough to burn. If the ratio of solid waste to sludge is great enough, a surplus of energy will exist, and it can be recovered in a boiler system. Steam can be sold or used to generate electricity for the co-disposal facility and wastewater plant operation or for distribution into the public utility grid.

Although there are only two operational co-disposal facilities in the United States, several are planned or are under construction as shown in Table 2-12. Different types of incinerators and equipment for sludge processing are being tried, with the basic operations being a mechanical system for dewatering the sludge prior to incineration, a solid waste and sludge feed system, a thermal sludge dewatering system, an incinerator heat recovery system, and an air emissions control device.

If the co-disposal facility is remote from the wastewater treatment plant, the sludge dewatering process begins at the wastewater treatment plant and is completed at the incineration facility as shown in Figure 2-8.

TABLE 2-12. U.S.A. CO-DISPOSAL SYSTEMS

	Capacity TPD					
Location	Sludge (wet weight)	Refuse	Type of sludge dewatering/drying	Type of incinerator	Projected cost (millions)	Status
Duluth	370 @ 18% solids	400	Vacuum filter	Fluidized bed	20	Start-up
Glen Cove	25 @ 20% solids	250 200	Centrifuge	Two 125-TPD reciprocating stokers	25	
Contra Costa	(12 - 18% solids) >1:3 sludge:RDF	1200	Lime plant centrifuge	Pyrolysis (SAC) multihearth	50	Planning EIS
Harrisburg	48 @ 85% solids	720	Vacuum filter to 22% steam dryer to 85% Porcupine	Martin (German) UOP, Chicago waterwall - steam Recip. grate stoker	30	Start-up wet end on line
Ansonia	55 (dried only for fertilizer)	200	Spray dryer	Rocking grate		Operational
Eastman Kodak	114 @ 20% solids	180	Spray dryer	Suspension with dump grate	Not known	Operational
Memphis	1225 @ 20% solids	2400	Belt filter press	Multihearth (spreader-stoker backup)	140	Final design
Holyoke	3 @ 85% solids	225	Vacuum filter, rotary kiln (85% solids)	Not known	Not known	Shut down* 1976-1977
Stanford	10 @ 75% solids	330	Centrifuge, rotary kiln	Not known	Not known	Not known

* System was shut down due to air pollution problems.

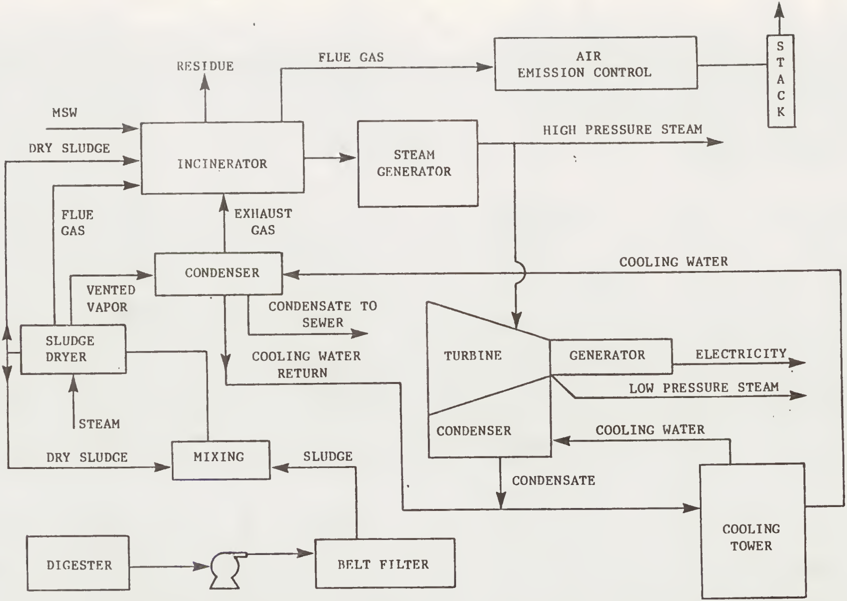


Figure 2-8. Flow diagram for 20 percent solids sludge drying with energy recovery.

The sewage sludge is dewatered mechanically at the treatment plant and then thermally dried at the incineration plant because of the availability of steam at the incinerator. The mechanical dewatering of the wastewater can be done by first centrifuging and subsequently using a belt filter. The resulting sludge cake is 70 to 80 percent water and is in a solid form. The cake is loaded into a truck and delivered to the incineration plant where it is stored.

The cake is then fed uniformly and continuously into the thermal sludge drier. Steam from the boiler system, in the amount of about 1.1 lb of steam needed to dry 1 lb of sludge, heats the sludge and evaporates the water from it. The dried sludge has about 15 to 20 percent moisture and can be fed by a screw conveyor into the incinerator charging hopper along with the solid waste. Mechanical dewatering processes are used extensively in the treatment of wastewater, and their operational and maintenance costs are fairly well documented. The major operating costs associated with the process are for the required polymers, chemicals, labor, and electricity. The thermal drying of the sludge cake is less frequently utilized in the treatment of wastewater than the mechanical system, and, consequently, operational and maintenance data on this process are not well documented. With the energy for drying supplied by the incinerator, the major cost items would be labor and maintenance.

Certain system advantages can be realized if the co-disposal facility is located at the wastewater treatment plant and if there is no local market for steam. The mechanical dewatering step could be eliminated as shown in Figure 2-9. Operational savings would be realized from the elimination of the chemical and polymer additives. Intermediate transportation or storage would not be required, thereby generating additional operational savings. The sludge, at approximately 96 percent moisture, would be pumped from the gravity or flotation thickener to the thermal drier. A direct drier system could be utilized. This system uses the hot flue gases, not steam, to evaporate the water. However, to achieve the desired low moisture level, the thermal drier must be larger and must consume more energy (to remove the extra water content of the sludge) than the system which utilizes mechanical dewatering. If there is no market for steam, the flue gases from the incinerator can be utilized directly in the sludge drier, and the capital costs of a boiler system would not be required. This type of drier, fired by auxiliary fuel, is being used to process municipal sludge in several cities in the United States.

ENVIRONMENTAL CONSIDERATIONS

The co-disposal facility will impact the environment in terms of potential air, water, and land pollution and the local aesthetics in terms of noise, odor, traffic, and visual effects. The technology exists to control the environmental impacts. Air emissions control devices, wastewater treatment plants, and properly designed and operated landfill sites should minimize the environmental impacts. Air emission control devices can reduce stack emissions and eliminate odors. Wastewater treatment plants can treat the water discharges from the sludge handling, drying, and storage systems. The residue from the incineration system can be properly disposed of at a

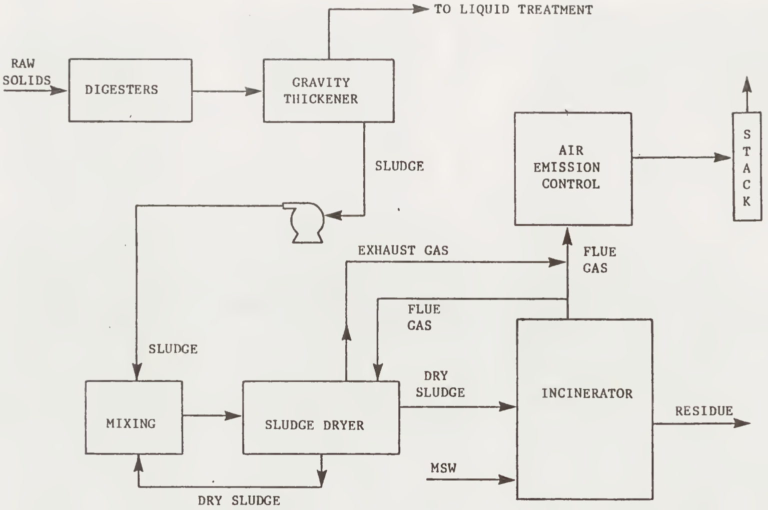


Figure 2-9. Flow diagram for 5 percent solids sludge drying and burning without energy recovery.

Class II landfill site to prevent potential groundwater pollution. Site location and careful facility design and operation should minimize the aesthetic effects. The cost of these control systems and design features will significantly impact facility economics by increasing capital and operational costs.

PLANT OPERATION

The operation of an incinerator with a heat recovery system is a difficult task in itself. The addition of sludge storage, drying, and handling systems further complicates the process. Electricity generation adds even another dimension to the operational aspects of the facility. Operation of the energy producing co-disposal facility would impact the daily operations of the sewage treatment plant, the sanitary landfill, the solid waste collection, and the energy customer. The co-disposal equipment design must provide reliability or redundant capabilities or economical and manageable alternative actions must be possible to provide continued services in the subject area.

The co-disposal of MSW and sewage sludge in the United States has thus far been mainly developmental. There is little operational data to appraise its technical and economic performance. Attempts to adapt European experience have met with little success because of the differences between American and European operating practices and philosophies.

CO-DISPOSAL IN HELENA

There are two potential alternatives for the location of a co-disposal facility in Helena, at the wastewater plant or at an energy customer's facility. Regardless of which alternative is selected, the wastewater plant design should include an additional primary digester and twin secondary digesters. The new primary digester is required to maintain relatively constant liquid levels in the process and to thoroughly mix the sludge to optimize methane production and sludge stabilization. The existing sludge storage tanks should be converted to secondary digesters by equipping them with floating covers. To promote settling of the digested solids and to allow decanting of supernatant liquid, they will not have any mixing or supplemental heating. The decanted supernatant would be returned to the existing liquid treatment process.

This system concept will eliminate any potential problems with handling, transporting, and storing unstable primary sludge. Odors through the production of toxic, noxious, and corrosive gases can be generated from primary sludge as it continues to decompose. Stabilization of the primary sludge through pH adjustment requires massive doses of lime or chlorine which are costly and difficult to control, as evidenced by the existing Purox system operation. Land application would provide a viable sludge disposal alternative if a co-disposal facility is not constructed. Land application of sludge can also serve as the backup system if the co-disposal facility is built. The system described above is Alternative 4 as presented in the Helena - Helena Valley Wastewater Facilities Plan by Peccia & Associates.

The wastewater facilities plan quantified and analyzed the sewage sludge. It was determined that on a dry basis 2,000 to 4,00 lb/day of primary sludge and 2,000 to 5,000 lb/day of secondary sludge will be collected. Knowledge of the fuel value of the sludge is required to determine the energy production of the plant. The individual components of sewage sludge such as grease and garbage have an energy value of 4,000 to 10,000 Btu/lb on a dry basis. Overall, the EPA has found the average heating value on a dry basis is 9,500 Btu/lb for raw, untreated sludge and 5,500 Btu/lb for anaerobically digested primary sludge. These values vary widely across the United States because sludge components and the chemical additives used to treat sludge vary widely. Only site specific tests can accurately determine the actual heating values. Other sludge parameters of importance to combustion are sulfur, chlorine, ash, and trace metals contents. The sulfur, chlorine, and trace metals contents were found to be low. Tests for the heating value on a dry basis were conducted by SYSTECH. The primary sludge was found to have 9,200 Btu/lb, and the secondary sludge had 8,900 Btu/lb. Table 2-13 presents the results of analysis on the sludge.

TABLE 2-13. HELENA, MONTANA, CHARACTERISTICS OF SLUDGE FROM EXISTING PUROX SYSTEM

Parameter	Primary	Secondary
Btu, per pound	9200	8900
Percent lb/lb		
Ash, @ 750°C	16.5	18.5
Sulfur	0.72	0.90
Chloride	0.02	0.02
Total metals, mg/ℓ*		
Cadmium	0.42	No data
Copper	47.90	No data
Manganese	3.00	No data
Lead	6.72	No data
Chromium	1.00	No data
Mercury	0.095	No data
Nickel	0.49	No data
Zinc	57.80	No data

* Helena - Helena Valley Wastewater Facilities Plan, Peccia & Associates, 1980, Appendix 2.

The new digester system will reduce the heating value of the sludge by destroying more of the volatiles. The sludge should be retested when the new system is constructed. A conservative value of 4,500 Btu/lb, similar to that of the solid waste, will be used for calculation purposes in this evaluation. Although the actual number will be higher, the feed rate of the sludge is so small compared to the refuse that the impact will not be significant.

SECTION 3

ENGINEERING DESIGN AND ECONOMICS

PRELIMINARY DESIGN

Introduction

The Part 1 interim report revealed two potential sites for an incinerator with heat recovery, the Fort Harrison facility and the State Capitol Complex. Further analyses of these sites are presented herein. A preliminary site layout, description, and estimated costs are developed for each of the sites.

Review of both candidate sites has indicated that implementation of any system would require 9 to 24 months for review and an additional 18 to 24 months for completion. Full operational capacity would not be reached until 1984 for the Fort Harrison site and 1985 for the Capitol Complex.

The solid waste-to-energy facility studied consists of an office and scale house, a tipping and storage floor, and an equipment room. The following sections describe the proposed facilities and equipment. Although only steam generation is recommended at this time, sludge drying and electrical generation equipment are also discussed.

Equipment Description

Incinerators--

There are several technologies commercially available for burning municipal solid waste and recovering energy. To select the most applicable, three criteria must be addressed. The first criterion is the degree of volume reduction of the solid waste required in relation to the amount of land available for landfilling. The second criterion is the efficiency of energy recovered in a compatible product in relation to the energy market demand. Capital and operational costs versus potential revenues is the third criterion. Analysis of the Helena, Montana, situation in Section 1 of the study indicated that the third criterion, costs, was the important factor, therefore, the starved air modular incinerator was selected.

The starved air modular incinerator that has a demonstrated capability of burning MSW is manufactured by Consumat Systems Incorporated, Richmond, Virginia. Two 100-TPD facilities have been in operation for more than 2 years on a 5-day/wk, 24 hr/day basis, and several are currently in the start-up phase.

The flat hearth, starved air system represents the general configuration and operational mode of the modular incinerators (see Figure 3-1). This system is a 2-chamber design, with partial combustion occurring in the first horizontal chamber and more complete combustion occurring in the secondary chamber (afterburner). The secondary chamber is operated in the excess air mode at approximately 1800°F. The higher temperature and the turbulence resulting from the excess air act to complete combustion. Most starved air incinerators are equipped with automatic feed systems which deposit the waste into the primary chamber. The waste is then pushed through the primary chamber by internal transfer rams until the resultant residue falls into the water sump. The residue is then automatically removed by a drag chain. The flue gases pass through a water tube boiler to generate steam or hot water. Air pollution control equipment is usually not required as a result of the small capacity of the units which places them in a less restrictive regulatory class. However, because the Capitol Complex facility is over 50 TPD, a control device will be required to meet federal emission regulations.

Operational experience is available on these systems for incineration of MSW and industrial wastes. Although they have been shown capable of co-disposal in test runs by the manufacturer, there are no systems currently operating in such a fashion. One system is planned jointly by the Linden-Roselle Sewerage Authority and the Rahway Valley Sewerage Authority in New Jersey to burn dry sludge at a rate of 30 TPD along with 50 TPD of refuse.

Figure 3-2 is representative of a small system layout. At a typical facility, the waste is unloaded onto the tipping floor which also serves as a waste storage area. The waste is moved from the tipping floor to the loading area of the combustor, usually by a small front-end loader or a skid-steer loader. These systems can burn as-received MSW. The area required for a 100-TPD installation is approximately 1 to 2 acres with a processing building of about 16,000 ft^2. The thermal efficiencies of these systems usually range between 50 and 60 percent. The thermal efficiency depends on the operational efficiency and the refuse characteristics. There are no long-term (over 2 years) operation and maintenance data on these municipal systems.

Starved air incinerators may be incorporated with either fire or water tube waste heat boilers to generate steam. The water tube design has the feedwater flowing through the tubes while the hot gases pass over the tubes. The fire tube design operates in the opposite mode; the hot gases pass through the tubes while the feedwater passes over the tubes. In the size range of the proposed facility, the water tube boiler is preferred. It can produce 450 psi of saturated steam for electrical generation. Operation to obtain higher pressure steam will not improve the conversion efficiency of steam to electricity in the turbine generator. Increasing the conversion efficiency would require using dry, superheated steam produced by a more complicated and expensive boiler. This type of boiler application has not been demonstrated with the modular incinerators.

The starved air incinerators are not capable of complete burnout of the refuse. Therefore, the amount of residue per ton of refuse burned can be

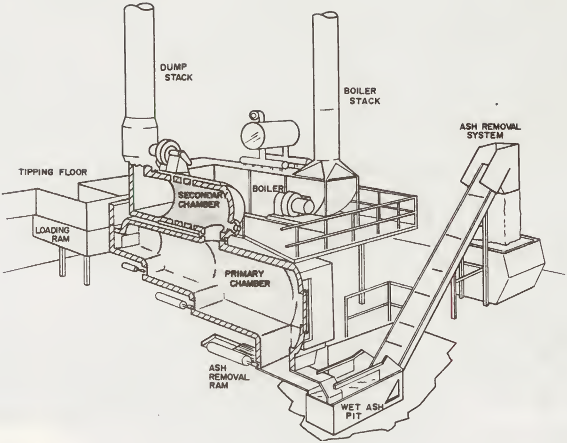


Figure 3-1. Consumat incinerator/heat recovery system.

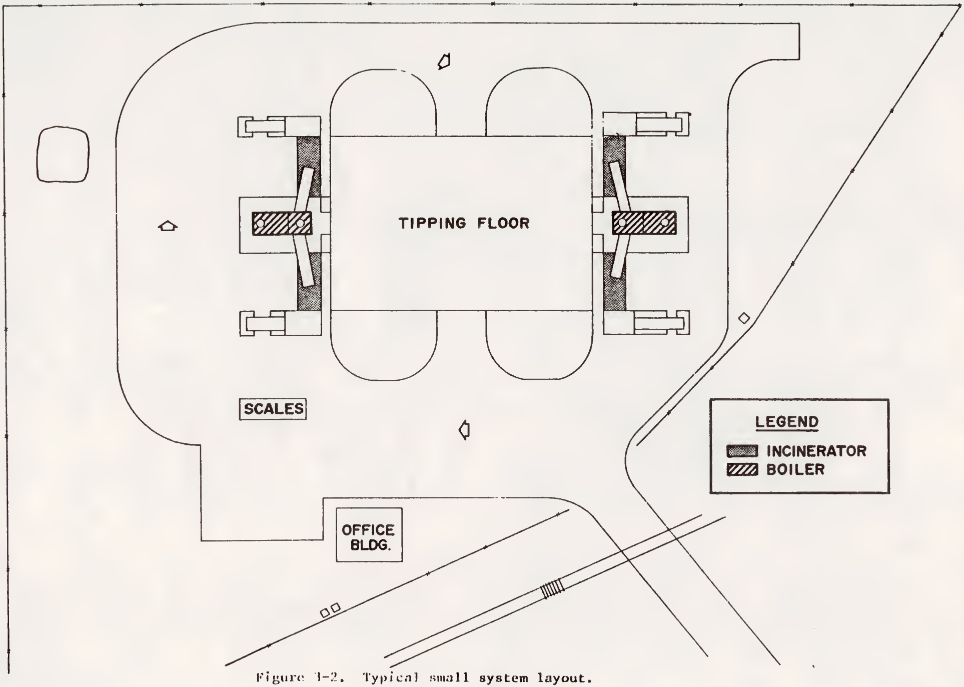


Figure 3-2. Typical small system layout.

greater than with other technologies. This puts a larger burden on the landfill site. Directly related to the lower burnout is the lower usable energy output, as less pounds of usable steam are generated per ton of refuse burned than in other systems. The energy market must be compatible with the lower output. However, in the area of the third criterion, the starved air systems have the lowest capital costs per ton of daily capacity of any other technology in the 50- to 100-TPD capacity range. Recent starved air facilities have been constructed for $25 to $30/ton of daily capacity while other technologies have cost $40 to $60/ton of daily capacity.

Sludge Dryer

An indirect heat exchanger system dries the sludge by contacting it with hollow- or double-wall surfaces which are heated by steam passing through them (see Figure 3-3). Indirect heat exchangers are typically horizontal vessels with a tubular rotor through the center. Attached to the rotor are double-walled paddles or discs which increase the heat exchange surface area. Steam flows through the rotor, discs or paddles, and vessel jacket, thus providing the heated surface area. Stationary agitator plows or scraper bars are located between the flights to achieve better mixing and to prevent material buildup on the heat exchanger walls. The sludge is moved through the unit by adjustable conveying vanes. The Porcupine processor pictured in Figure 3-3 is currently undergoing testing at Harrisburg, Pennsylvania. Other manufacturers of dryers are given in Table 3-1. The moisture laden off-gas from the dryer is ducted into the incinerator where any organic particulates and odors are destroyed.

TABLE 3-1. VENDORS FOR INDIRECT HEATED SLUDGE DRYERS

Davenport Machine and Foundry Company
1628 W. Fourth Street
Davenport, IA 52808
(319) 322-6201

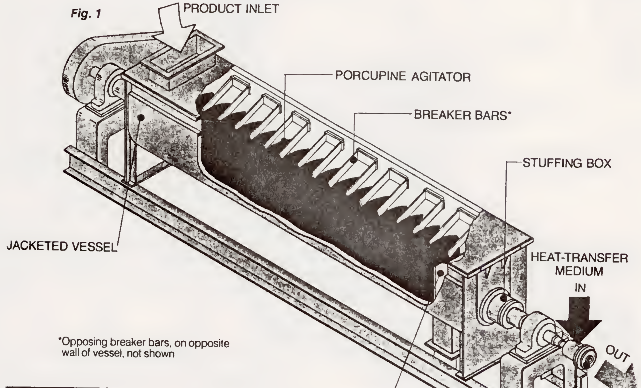
C. E. Raymond Combustion Engineering Inc.
200 W. Monroe Street
Chicago, IL 60606
(312) 236-4044

Bethlehem Corporation
The Process Equipment Group
25 and Lenox Streets
Easton, PA 18042
(215) 258-7111

SINGLE-SHAFT PORCUPINE® PROCESSOR

Cutaway shows unitized design.
Breaker bars (optional) enhance local mixing and assure self-cleaning, when required.

Fig. 1



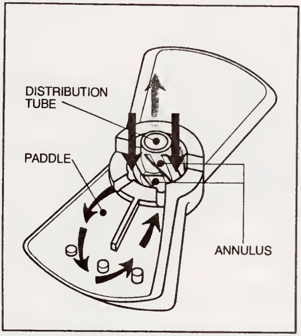


***Fig. 2** Paddle cutaway indicates flow of heat-transfer medium from paddle to paddle.*

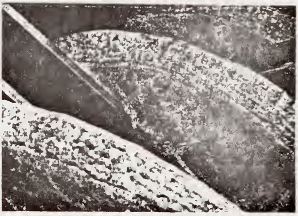


***Fig. 3** For severely abrasive applications, blade tips can be protected by hard surfacing. (Hard surfacing can be re-applied if severe wear occurs.)*

Figure 3-3. Details of Porcupine processor for drying sewage sludge.

Turbine Generator

For the proposed facility, the condensing or noncondensing turbine generator systems are applicable. The condensing turbine converts all the usable energy in the steam to electricity and exhausts negative pressure steam. The noncondensing turbine does not convert all the potential energy in the steam to electricity and, as a result, exhausts positive pressure steam which may be utilized elsewhere. Both are available as single stage or multistage package units which arrive on site factory assembled and tested.

The units discussed herein were chosen to operate at 450 psi saturated steam input. Several manufacturers of these systems are given in Table 3-2 and a typical cross section is shown in Figure 3-4.

TABLE 3-2. LISTING OF MANUFACTURERS AND SUPPLIERS OF PACKAGED POWER GENERATING EQUIPMENT

Trane Company
La Crosse, Wisconsin 54601

Thermo Electron Corporation
Energy Systems
101 First Avenue
Waltham, Massachusetts 02154

The O'Brien Machinery Company
260 Green Street
Dowingtown, Pennsylvania 19335

Condensing Turbine--

Electricity can be generated at a rate of approximately 10 percent of the energy input value to the incineration system. For example, at an input rate of 39.4×10^6 Btu/hr to the incinerator, 1036 kWh (or 3.5×10^6 Btu/hr) of electricity will be generated. In terms of steam delivered to the turbine, it requires about 15 lb of steam at 450 psi to generate 1 kW. This system converts all the usable energy in the steam to electricity. The condensed steam is returned to the boiler. The efficiency of the turbine, expressed as kW/lb of steam, is almost linear over the operating range of 25 to 100 percent of its capacity. However, near or below the 25 percent range, efficiency drops quickly.

Noncondensing Turbine--

These systems will generate steam at a rate of only 5 percent of the energy input value to the incineration system. For example, at an input rate

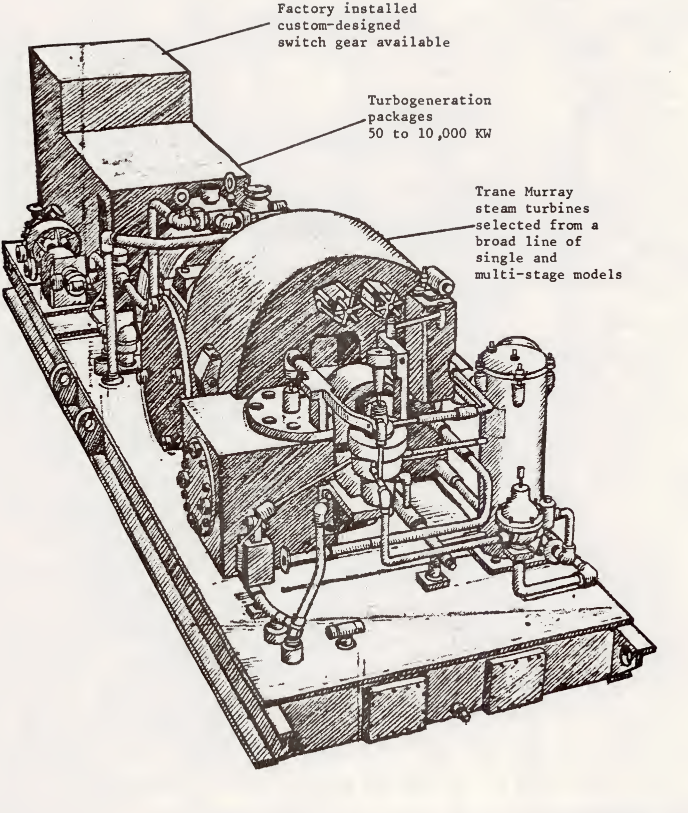


Figure 3-4. Typical packaged power generation equipment equipment as supplied by Trane-Murry.

of 39.4×10^6 Btu/hr to the incinerator, 407 kWh (or 1.7×10^6 Btu/hr) of electricity will be generated. In terms of steam delivered to the turbine, 32 lb of steam at 450 psi are required to produce 1 kW when the exhaust pressure is 30 psi. To compensate for the lower electrical output, this system also produces low pressure exhaust steam, which could be sold for heating or used in-house.

FACILITY DESCRIPTION AND CAPITAL COST

Introduction

The general layout of the two alternate facilities is similar with only the capacity and number of incinerators different. The general layout is shown in Figure 3-5. The layout provides for future additions of a sludge drying system adjacent to the incinerator. Space is also left within the building for the inclusion of a packaged turbine for electricity generation at a future date. Details of the layout are shown on the preliminary site drawings submitted under separate cover.

State Capitol Complex

The State Capitol Complex offers a slowly growing market in the areas of steam for heating and chilled water for cooling. An extensive distribution system would be required to supply all the buildings, and some of the heating plants would have to be modified.

The current average monthly heating demand exceeds the energy recoverable from the solid waste during the 3 peak heating months, November, December, and January. An excess of energy is available during the other months. By the time new buildings are constructed and the demand increases, the solid waste should also increase to continue to meet all but the 3 peak demand months.

A 100-TPD facility consisting of four 25-TPD units, operating 5 days/wk, would provide the best system for this complex. The existing main boiler plant would provide for the peak heating and any weekend demand. In 1980, there was an estimated 60 TPD available for burning when the individual contribution is removed. With the waste increasing at a projected 6 percent per year, 75 TPD would be available in 1985, the anticipated first year of operation. The 75 TPD available for burning in the winter requires the operation of only three units. The fourth incinerator will provide backup capacity to assure maximum output of steam in the winter. During the summer, over 100 TPD are available requiring the operation of the fourth unit. Any surplus solid waste would be routed directly to the landfill site.

The possible site(s) are shown in Figure 3-6. The building would require a concrete facing similar to the other structures in the complex. The steam tunnel distribution system would be located under the sidewalks around the site. Traffic would enter the site from Ninth Avenue and should not cause any problems with the residential areas located farther up the hill. Because of the location, only the commercial and municipal trucks should be allowed to

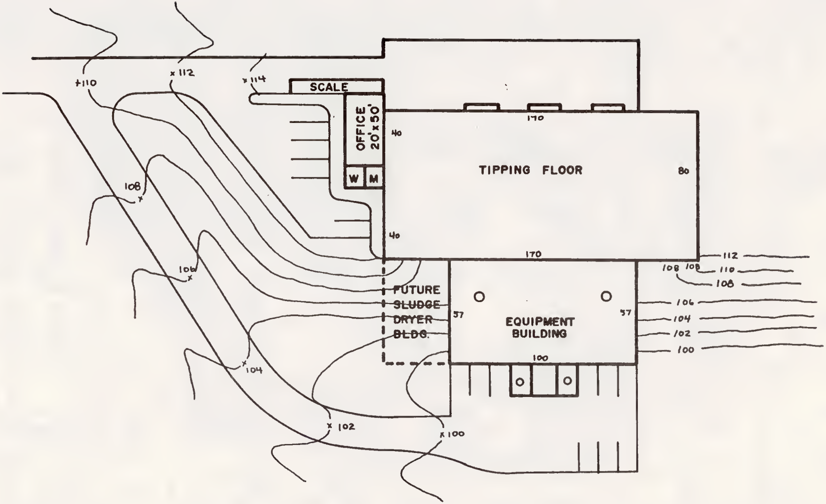


Figure 3-5. General site layout for waste-to-energy facility in Helena, Montana.

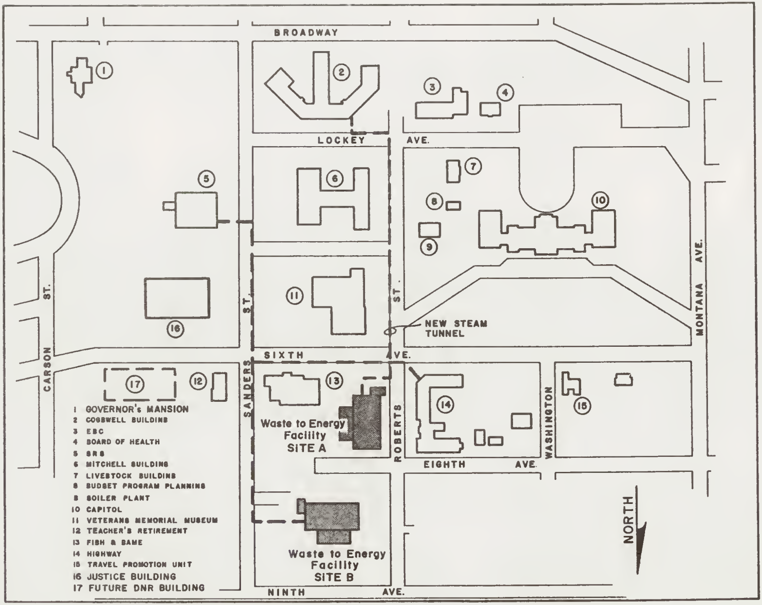


Figure 3-6. Site layout for State Capital Complex waste-to-energy facility in Helena, Montana.

use the facility so that a traffic problem is not created. Only the school and church areas will have direct visual contact with the site.

The 13,600 ft^2 tipping floor is designed to handle 100 TPD of incoming solid waste and to store 200 tons of waste. This capacity permits the option of 7-day/wk operation and storage of at least 1 day fuel supply as a hedge against delays in delivery.

The room beneath the control level is provided so that a package turbine can be installed at a future date. The enclosed room will keep the turbine and the electrical controls free of the solid waste and residue dust. This room will also contain the power transformers and electric panels. A locker room for the work crews will be located under the control level.

The residue removal system will discharge within the building to prevent freezing problems. The wet ash should not pose a problem within the structure. The residue will drop into a large dump truck and will require removal twice each day.

Fort Harrison Veterans Administration Hospital

The Fort Harrison site appears to be a stable market for steam heating and a remote candidate for chilled water. A proposed energy conservation program may be offset by a possible building expansion. The facility is not centrally air conditioned, but a chilled water system could be installed at some expense.

The amount of solid waste in Helena is more than enough to provide all the energy for the required heating energy demand. Although one 35-TPD unit would meet the demand, a 50-TPD facility consisting of two 25-TPD modules, operating 7 days/wk, would provide system capacity and unit redundancy. The total amount of waste required would be 350 tons per week which is almost all of the solid waste in the winter and 50 percent of the solid waste in the summer. The balance of the solid waste and incinerator residue would have to be landfilled. No private vehicles would be allowed at the site.

The 7-day operation would require up to eight more personnel than the four already employed at the boiler plant. The current boiler plant is sufficient to provide backup capacity in case one of the incineration units is not functioning.

A site layout is shown in Figure 3-7. The building should have a facing (brick) to match the other buildings on the Fort. A paved access road would have to be constructed from a back road to the site to divert refuse truck traffic from the main Fort area.

Since the facility will operate 7-days/wk and most of the solid waste would be received 5-day/wk, a significant portion of the tipping floor area must be utilized for storage of a 1- to 2-day supply (50 to 100 tons) of solid waste. Storage of the waste in piles approximately 7 ft high requires 50 ft^2 of floor space/ton, so a total of 5000 ft^2 is required

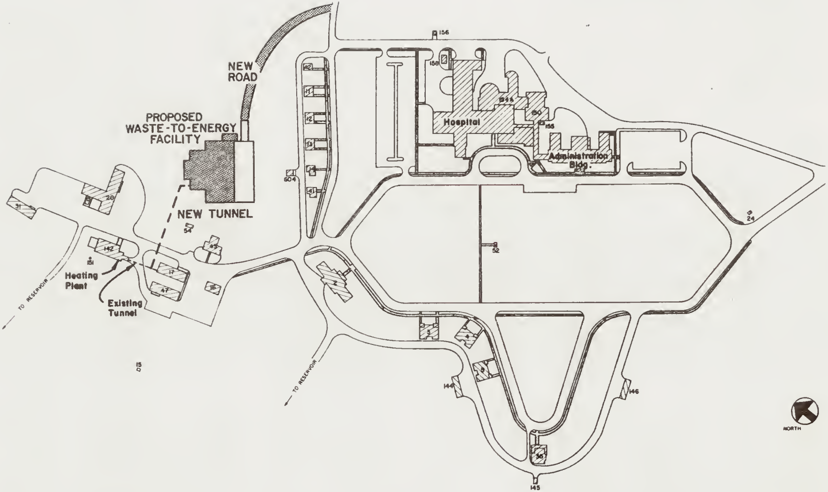


Figure 3-7. Site layout for waste-to-energy facility at Fort Harrison in Helena, Montana.

to store 100 tons. When space is allowed for truck and front loader movement, a tipping floor space of slightly more than one-half (shown in Figure 3-5) is required. Dimensions of the building could be 80 ft × 100 ft. Similarly, since only one pair of incinerators is utilized, the equipment building would be reduced to 57 ft × 75 ft.

The possibility of the inclusion of a sludge dryer and a turbine seem remote at this site, but space has been provided within the layout. The cost of this space is not considered a burden to the facility.

Capital Costs

The costs of the proposed facilities were estimated in 1981 dollars based on price quotes from manufacturers and prices of recent construction projects (Means Index). The estimated 1981 costs are presented in Table 3-3. The 1983 costs can be estimated by multiplying by a factor of 1.3 to allow for about 15 percent annual inflation.

Steam Generation--

The 100-TPD steam generating complex at the State Capitol would cost an estimated $5,244,000 in 1981. About $1,000,000, or 20 percent of the total costs, would be spent on the new distribution tunnel system and conversion of forced air heating systems.

The 50-TPD steam generating complex at Fort Harrison would cost an estimated $2,967,000 in 1981. This site would require an access road across a drain area and an exterior brick facing to match the other building. A steam tunnel of about 1000 ft in length would be required.

Power Generation--

The addition of a turbine generator would add approximately $300,000 to the equipment cost of the 100-TPD complex but would require no additional building costs. Power generating at the 50-TPD facility does not appear practical due to the extreme distance of the facility from the main power distribution point. Power generation for on-site consumption is a possibility at both sites, however, until the power rates and costs for backup service are completed under the PURPA changes, the benefits cannot be evaluated.

OPERATION AND MAINTENANCE COSTS

Annual operational costs have been reported from two 100-TPD, municipally operated, small modular incineration facilities generating 150 psi saturated steam. At North Little Rock, Arkansas, the total annual cost in 1978 was projected to be $12.55/ton, without amortization and before energy revenues, while operating at 75 percent of capacity. The source of the cost was an evaluation sponsored by the U.S. EPA. The city budget for the facility in Salem, Virginia, reported a total annual operating cost in 1979 of $13.90/ton, without amortization and before energy revenues, while operating at 80 percent of the plant capacity.

TABLE 3-3. ESTIMATED COSTS FOR WASTE-TO-ENERGY FACILITIES IN HELENA, MONTANA*

Item	Facility costs in $1,000 Fort Harrison 50 TPD	 Capitol Complex 100 TPD
General	$ 25	$ 25
Site preparation	106	106
Building	762	889
Access road	78	NA
Steam line	250	1,000
Air pollution control	113	225
Scale	50	50
Loaders (2) and residue truck	100	100
Legal and engineering	133	199
Incinerators/boilers installed	1,350	2,650
TOTAL	$2,967	$5,244

* These costs are based on 1981 estimates and do not include contingencies, land costs, or financing costs.

The projected annual costs in 1985 for labor, utilities, maintenance, and residue disposal are itemized and discussed in the following paragraphs. The costs are based on the 1978 evaluation of North Little Rock, Arkansas, and the Salem, Virginia, 1979 final budget; the 1980 proposed budget; and the first quarter actual costs. The costs for 1985 can be projected by applying a cost factor index to raise the value to 1981 dollars and by projecting the 1981 costs to 1985 by using an annual inflation rate. Annual inflation rates used in this evaluation are labor and utility costs at 10 percent and fuel, equipment, and landfill costs at 15 percent. The total costs are presented in Table 3-4.

OPERATION COSTS

Labor Costs

Operation of a starved air modular incinerator/energy recovery system up to 250-TPD capacity usually requires a minimum of ten persons: a plant supervisor, a secretary/accountant, two workers per shift, one maintenance person, and one residue disposal truck driver for a 5-day/wk operation. To operate 7-days/wk would require a minimum of an additional two workers and one residue truck driver. The average salaries per year, including benefits used in this analysis, are $35,000 for the supervisor, $15,000 for the secretary/accountant, and $23,000 for all others.

Management

The operation of the facility requires telephone, clerical, travel, and training costs which are relatively independent of facility capacity. The costs are estimated to total $3500 with 50 percent of this amount for telephone expenses.

Utilities

Fuel--

The modular incinerators use auxiliary fuel only during the start-up and shut-down periods which usually take a total of 4 hr/wk. The evaluation of the North Little Rock 100-TPD system found the auxiliary fuel to be 0.044 MMBtu/ton of refuse charged. The residue removal truck and the front loaders also consume a large amount of fuel. The North Little Rock evaluation found this value to be 0.69 gal/ton.

Electricity--

The total plant electricity consumption at North Little Rock was found to be 31 kWH/ton. The operation of the two baghouses will require approximately 4 kWH/ton for a total of 35 kWH/ton.

Water--

The water and sewer costs are going to vary depending on local situations such as the amount of condensate returned from the energy customer. Based on 75 percent condensate return, the water consumption would be about 15 gal/ton. The boiler blowdown is assumed to be an additional 10 percent of the steam

TABLE 3-4. ESTIMATED OPERATIONAL AND MAINTENANCE COSTS FOR A WASTE-TO-ENERGY FACILITY IN HELENA, MONTANA IN 1985

	Facility annual costs		
Item	Cost per ton	Fort Harrison 18,250 TPY	State Capitol Complex 23,200 TPY
Salaries of personnel	NA*	$445,900	$376,900
Management (telephone, supplies)	Fixed	3,500	3,500
Electric	$1.60	29,200	37,100
Fuels	$2.00	36,500	46,400
Water and sewer	$0.50	9,100	11,600
Materials, parts	Fixed	7,800	7,800
Residue disposal	$8.00	65,700	83,500
Maintenance	$6.40	116,800	148,500
TOTAL		$714,500	$715,300
O&M costs per ton		$39.15	$30.83

* Not applicable.

amount or about 6 gal/ton. In addition, water is used in large amounts to wash the floor and equipment throughout the week. This amount will also vary from facility to facility. Using the trend shown in the North Little Rock evaluation, two times as much water is used for washing as for steam. Due to the plant conditions during testing, this would be considered a conservative estimate (maximum amount). This brings the total water and sewer demand to 63 gal/ton.

Materials

The materials category includes spare parts and miscellaneous items such as thermocouples, timers, tools, lights, etc. This is not a large item, only 2.5 percent of the 1980 Salem operational budget, and it is more than likely independent of the facility size. An amount of $7800 will be utilized as an estimate.

Residue Disposal

The disposal of the residue involves the fee for dumping the waste at the landfill site. This cost is $8/ton based on the projected cost per ton to operate a landfill site near Helena, Montana. The annual residue weight is 45 percent of the annual charging rate and is about 35 percent by weight quench water.

Maintenance

Maintenance costs are spread through the salary and materials items as well as this item which includes the large replacement parts, refractory repairs, front loader, residue truck items, and general plant maintenance. This item was found to be $3.33/ton in the 1979 North Little Rock evaluation. The 1980 Salem budget had $2.02/ton maintenance costs budgeted, but the actual first quarter costs (due to some mechanical problems) were closer to $4/ton, or 4 percent of the 1978 capital costs.

The U.S. EPA recommends using 5 percent of the capital costs for annual maintenance, but this includes labor and all parts. Exclusion of labor from the maintenance costs in the North Little Rock evaluation leaves the remainder at 3 percent of the capital costs. The intermediate, more conservative annual rate of $4/ton was used in this evaluation. Maintenance costs are projected to be $6.40/ton in 1985.

AMORTIZATION

The capital costs of the facility are recovered through amortization of the initial costs through the useful life of the various individual pieces of equipment. The useful life of the major equipment is estimated to be 15 years, while that of the front loader is estimated at 2 years, and the residue truck and containers is estimated at 7 years. However, for purposes of the evaluation, the relative small costs of the rolling stock should be included in the much larger major equipment costs so that the 15-yr life will be applied to the total facility. Sources and outlook of financing will be developed and presented in Part 3 of this evaluation.

REVENUES AND NET COSTS

State Capitol Complex

The State Capitol Complex offers a slowly growing market in the areas of steam for heating and chilled water for cooling. The current monthly average heating demand exceeds the heat recoverable from the solid waste during the 3 peak heating months: November, December, and January. The predicted amount of solid waste will not meet this demand until the year 2000. Table 3-5 summarizes the economics of the sale of steam for heating several alternate systems. Case I involves the current buildings that use hot water or steam heating systems. Case Ia includes the conversion of the forced air system in the SRS Building to steam in addition to the buildings in Case I. Case II projects the addition of a new building to Case I, while Case IIa includes the proposed building in Case I and the SRS Building. These alternatives allow the review of the costs versus predicted revenues for converting the SRS Building heating system and the projected revenue increase due to the addition of new buildings at $\$3.40/10^6$ Btu in 1981 projected to 1985 by 15 percent increases.

Although some of the buildings have window units, most use electric coolers to produce chilled water for central air conditioning. The major air conditioning demand is for a 6-mo period. However, there are several computer rooms that are air conditioned all year. The current annual costs for air conditioning are approximately $43,000 for electric and $64,000 for maintenance. To obtain the potential income from the air conditioning, a central cooling loop would have to be constructed along with the steam logs and modification would have to be made to permit use of chilled water in each of the buildings. These costs are included in the estimate of capital construction costs.

Most of these costs could be revenues to the proposed facility if an absorption chiller and distribution system are installed. Additional chilled water demand will occur when the Justice Building is completed and if another building is constructed. Based on heating demand versus square footage, the Justice building will increase the revenues 15 percent and the proposed building an additional 10 percent. The 1985 chilled water demand is projected to be 1.25 times the 1981 demand.

The revenues from the disposal of solid waste in 1985 are estimated to be about $8.00/ton based on a rate of $5.20/ton landfill costs in 1981 and an increase of approximately 15 percent/yr. At 100 percent of plant capacity, the annual disposal revenues would be $186,000 in 1985. Total estimated annual revenues from the 100-TPD facility at the Capitol Complex would be $885,000/yr in 1985.

TABLE 3-5. SUMMARY OF PROJECTED 1985 ANNUAL REVENUES FROM A 100 TPD FACILITY AT THE STATE CAPITOL COMPLEX, BASED ON A 5 DAY/WK OPERATION

Revenues	Dollars 1985
Steam sales	
Case I*	$462,000
Case Ia†	495,000
Case II§	486,000
Case IIa‡	517,000
Chilled water	
All cases	182,000
Solid waste disposal	186,000
Total**	$885,000

* Case I - Capitol Complex boiler, Fish and Game, Justice Department, and Cogswell addition.

† Case Ia - Capitol Complex boiler, Fish and Game, Justice Department, Cogswell addition, and SRS.

§ Case II - Capitol Complex boiler, Fish and Game, Justice Department, Cogswell addition, and future building.

‡ Case IIa - Capitol Complex boiler, Fish and Game, Justice Department, Cogswell addition, future building, and SRS.

** Total utilizing maximum steam revenues (Case IIa).

FORT HARRISON VETERANS ADMINISTRATION HOSPITAL

The Fort Harrison site appears to be a stable market for steam heating and a remote candidate for chilled water. A proposed energy conservation program should decrease the current heating demand, but a potential expansion would restore it to the original level. The facility is not centrally air conditioned at this time, but a chilled water system could be installed if the SWTE facility were constructed. The amount of energy from the solid waste is more than enough to meet the existing heating demand. No estimates of the chilled water market is made due to its uncertainty of completion.

Revenues from the generation of steam are predicted to be $332,000 in 1985 as shown in Table 3-6. A solid waste disposal fee of $8.00/ton, as explained above, will generate an 1985 annual revenue of $153,000. The total revenue will be approximately $485,000 in 1985.

TABLE 3-6. SUMMARY OF PROJECTED 1985 ANNUAL REVENUES FROM A 50 TPD FACILITY AT FORT HARRISON BASED ON A 7 DAY/WK OPERATION

Revenues	Dollars 1985
Steam sales	$332,000
Solid waste disposal	153,000
Total	$485,000

Net Operating Costs

Tables 3-7 and 3-8 present scenarios which reflect inflation rates of 15 percent on energy and waste disposal related items in the operational costs and revenues. The total operation and maintenance costs of the Capitol Complex facility could range from $29,400,000 to $32,100,000 over the 15 year life of the facility. The total revenues could range from $29,500,000 (based on landfill and energy costs inflating 5 and 10 percent respectively), to $49,300,000 when 15 percent inflation is used for both items for the same time period.

The proposed facility at Fort Harrison could require $28,600,000 to $30,750,000 for operation and maintenance over the 15-yr life of the facility. The total revenue could range from only $15,500,000 (based on landfill costs and energy costs inflating 5 and 10 percent, respectively) to $27,000,000 when 15 percent inflation is used for both items.

TABLE 3-7. STATE CAPITOL COMPLEX WASTE-TO-ENERGY FACILITY PROJECTED NET OPERATING REVENUES AT 15 PERCENT ANNUAL INFLATION OF ENERGY AND SOLID WASTE DISPOSAL RELATED ITEMS

	Dollars × 1,000			
	1985	1990	1995	2000
Operating and maintenance (cost)	(715)	(1,282)	(2,325)	(4,268)
Disposal fees	186	373	752	1,512
Energy sales	699	1,407	2,822	5,689
Debt service	(1,180)	(1,180)	(1,180)	(1,180)
Net revenue (cost)	(1,010)	(682)	69	1,753

TABLE 3-8. FORT HARRISON WASTE-TO-ENERGY FACILITY PROJECTED NET OPERATING REVENUES AT 15 PERCENT ANNUAL INFLATION OF ENERGY AND SOLID WASTE DISPOSAL RELATED ITEMS

	Dollars × 1,000			
	1985	1990	1995	2000
Operating and maintenance (cost)	(715)	(1,253)	(2,225)	(3,998)
Disposal fees	153	308	618	1,245
Energy sales	332	668	1,344	2,701
Debt service	(675)	(675)	(675)	(675)
Net revenue (cost)	(905)	(952)	(938)	(727)

The operation and maintenance costs are relatively stable in relation to the predicted inflation rates. However, the revenues are greatly affected. Energy cost projects by government and private agencies favor the 15 percent rate as the average value of annual inflation. A large price increase with the current 1985 deregulation of natural gas has been accounted for in this average inflation rate. If, however, deregulation occurs before 1985, the price projection would shift, and the 1985 and beyond natural gas costs would increase.

Debt Service

Although the details of each site are not completed, the costs of debt retirement can be estimated if some assumptions are made. Assuming that the facility will be financed by government bonds, over the predicted life of 15 years, the annual debt service payments will be $146,820 per million dollars borrowed (financed when the bond interest rate is 12 percent).

Inflating the projected 1981 capital costs with an annual inflation rate of 10 percent results in a capital investment of $6,200,000 at the capital facility in 1983. In addition, 2 years interest and 6 months operational costs should be included in the bond issue. The interest totals approximately $1,500,000 and the operational cost is about $350,000. The total bond issue would be for approximately $8,050,000. Thus the annual payments beginning in 1985 would be $1,180,000 and the 15 years total would be $17,700,000.

At the Fort Harrison site the 1983 capital costs would be about $3,500,000. The interest and operational costs would be about $1,100,000. The total costs of the bond would be $4,500,000. The annual debt payments would be $675,400 and the 15-yr total would be $10,100,000.

SECTION 4

IMPLEMENTATION STRATEGIES

ORGANIZATION

The ownership, procurement, and finances of a waste-to-energy facility are complexly intertwined. Because of this, there are several individuals who should be involved to form a team that puts together the project. The parties to the team and their responsibilities generally are:

1. Legal counsel - to provide day-to-day legal services and to negotiate the energy and service agreements.

2. Bond and underwriter counsel - to provide opinions on tax-exempt status of bond issue and to ensure that all financing documents are correct.

3. Tax counsel - to define the tax advantages of participating parties.

4. Independent engineering firm - to provide a technical and economic evaluation of the project.

5. Investment bankers and advisors - to develop a sound financing plan and to procure the bonds for project funding.

PROCUREMENT

The team works together to procure the facility utilizing one of three general approaches (1) Architectural and Engineering (A&E), (2) Turnkey Contract, and (3) Full Service Contract. Among the many factors affecting the selection of a procurement approach, the most significant is probably associated with risk management. Risk management can be defined as a "well thought out decision on how much risk will be absorbed by the individual participants." This decision is often economic because of the close relationship between cost and risk. There are essentially three ways of managing risk: (1) accept the risk, (2) transfer the risk, or (3) reduce the risk. All these factors involve a cost factor. Generally speaking, the greater the risk, the greater the potential for unknown costs. Conversely, as more of the risk is transferred, the potential for unknown costs is reduced, however, the known costs are higher. A discussion of the various procurement approaches and their impact on risk management follows.

Architectural and Engineering Approach

Probably most commonly used by governmental agencies, this approach has two phases: (1) select an A&E firm for the custom design of the facility and (2) acquire through competitive bidding, a general contractor for the construction of the facility. Obviously the success of this approach depends on the experience and the capabilities of the A&E firm to design a workable system. Since the contractor's responsibility is simply constructing to all design specifications, the owner must modify the facility with his/her own finances whenever modifications are needed for proper system performance. This approach is technology limited in that some of the current resource recovery processes are patented. With this approach, the owner finances the facility and can either operate the facility or lease it to a private operator.

In risk management this approach generally provides the owner with the lowest first cost requirement. However, the owner and the A&E firm accept all of the risks associated with system performance.

Turnkey Contract Approach

Under the turnkey contract approach, the owner hires a systems contractor to design, build, and start up a resource recovery system. The owner initiates this type of approach by issuing a Request for Proposals (RFP) that states, in general terms, the performance requirements for the facility. After evaluating the returned proposals, the owner selects a contractor on the basis of both the system cost and the contractor capabilities. This approach offers several advantages in that the design may include unique and/or patented processes, the contractor can integrate many empirically determined factors into a comprehensively designed facility, and the owner does not have to accept the risk of the facility until the system has met the performance specifications. However, there is the disadvantage that the contractor's liability is generally limited to the acceptance of the facility. The contractor, therefore, has no incentive to design and build a plant for long-term durability or easy maintenance. The owner can minimize this disadvantage by retaining an engineering consultant who can determine whether the system's durability, required maintenance, and general operation are acceptable.

The second major negative factor is that this procurement approach can be more expensive on a "first cost" basis than the A&E approach. The reason for this is that the turnkey contractor must absorb all risks until the owner's acceptance of the facility, and he must charge enough to cover his risks. This potential for higher cost must be considered in the owner's risk management decision process. As in the A&E approach, the owner himself/herself can operate the facility or can contract for private operation.

Full Service Contract Approach

Unlike the previous two procurement approaches, the full service contract approach is an option where the owner does not want to finance, own, or operate the resource recovery facility. In essence, the owner is procuring a waste disposal service rather than a facility. In addition to financing, constructing, operating, and maintaining the resource recovery plant, the contractor must ensure the continuance of prescribed services over the contract life.

With this type of contract, the owner normally requires the contractor to provide for the disposal of a certain number of tons per day, week, etc. In return, the contractor charges a predetermined rate, usually on a per ton basis. Normally such contracts have provisions for the escalation of operating costs. While this approach has the advantage of no risk for the owner, it has the disadvantage of the high disposal rates that the city must pay because of the contractor's assuming all financial and operational responsibilities.

With the full service contract approach, the system financing is the contractor's responsibility. The private sector has financing alternatives that are similar to those discussed in the section on financing. Two other financing alternatives, leverage leasing and industrial revenue bonds, are also available and involve the city in their issuance. Advantages of these approaches to the contractor include lower interest rates than other types of bonds and the maintenance of tax benefits such as capital depreciation and investment tax credit. Because these factors reduce the contractor's costs, a lower cost can be quoted to the owner.

FINANCING

There are three basic types of financing for waste-to-energy facilities. They are presented and discussed in the following paragraphs.

General Obligation Bond Financing

A city, county, or state government issues bonds to finance the facility and pledges its full faith and credit to guarantee payment of the bonds. While most cities are not considering this approach, it provides the lowest interest rate and finance charges and should always be considered in any project. They generally require voter approval, and there are generally stuatory limits of this type of debt.

Revenue Bonds

Tax-exempt revenue bonds are used to finance the project, and revenues from the project are pledged to secure the bonds. However, covenants from the project participants are required to ensure that revenues will be sufficient to meet that pledge. The nature of this financing allows a private corporation to operate the facility and capture the tax benefits of ownership. In such a case, the private operator should be expected to make construction and operation guarantees. These types of bonds do not require voter approval, are backed by only the projected revenues of the project, and generally have a higher interest rate than general obligation bonds.

Leveraged Lease Financing

Leverage leasing is an approach that generally involves three parties: the owner of the waste stream (city), the operator, and a private investor. With this approach, the city procures a facility that is owned by a private investor. Usually up to 40 percent of the needed funding is provided by the investor with the balance secured through a revenue bond issue. The investor is the facility owner and therefore captures the appropriate tax advantages. The facility operator, who may also be the investor, leases the facility from the owner and provides the system construction and operation guarantees. Often times, this procurement approach has provisions for an option of ownership of the facility by the city after a certain period of time.

CONTRACTING

Implementation of a waste-to-energy facility requires contracts with such entities as: consultants who conduct feasibility analyses, A&E firms which design the facility, general contractors who construct the facility, and other concerns who will operate the facility. Since governmental agencies routinely establish contracts such as these, appropriate contractual procedures are normally well defined and can be readily applied.

Waste-to-energy systems also have a requirement for contracts that are different from those typically used by municipalities. Most significant is the requirement for long-term contracts with other public agencies, quasi-public agencies, and/or private concerns. These contracts, which may include a dedicated waste supply or a market commitment, are necessary to ensure continuance of the financial base throughout the life of the facility. This requirement for long-term contracts is a unique aspect of a waste-to-energy system and may even present a conflict with established procedures. Many cities and states have statutes that prohibit long-term contracts.

GUARANTEE

Numerous businesses and industries produce much of the solid waste currently collected by the city and private haulers. As the value of recovered resource and energy products increases, many companies will likely exploit the recovery of such products in their waste. Obviously the city would then no longer be able to control the usage of these wastes. In order to control these factors, contracts are necessary to guarantee the waste stream supply and the energy user.

Waste stream guarantees include assurances about the quantity and composition of the municipal waste to be delivered. Guarantees deal with the number of tons of garbage that a facility accepts and the amount of energy and the type of materials to be recovered. Minimum energy purchase commitments and the price for all the energy delivered are the guarantees needed from the energy user.

The capital and economic costs of a resource recovery facility will be determined in part by these guarantees. The facility will receive payments from the disposal of municipal waste and from the sale of recovered energy. Waste stream and energy user guarantees will help to determine the amount of these revenues.

REVENUES

The debt service resulting from the expenditure of capital to build the facility generally remains constant over the lifetime of the facility and is paid off in equal installments. Operating and maintenance (O&M) costs will rise according to the rate of inflation. Energy revenues will also increase and parallel the rise of prices for alternative fuels.

Recent events have caused energy prices to rise faster than O&M costs, and it is believed that this situation will continue in the future. As a result, revenues should increase at a greater rate than plant costs over the lifetime of a waste-to-energy facility.

PROGRAM SCHEDULING

The program to construct a waste-to-energy facility involves nine general steps: (1) select the site, (2) secure financial approval, (3) negotiate the contract, (4) send out RPF, (5) submit final design, (6) obtain bonds, (7) construct the facility, (8) provide start-up and shakedown, and (9) complete the acceptance testing.

Site selection involves obtaining zoning approval, receiving air emissions and solid waste disposal permits, securing public acceptance (hearings), and receiving approval of the State of Montana Legislature or the Federal Office of Veterans Administration. The item which would require the longest time frame to complete is approval by the legislature which could take some 18 months or until their next session. The other items could be completed concurrently within 9 months.

The method of financing needs to be developed. This depends on the final site selection. Because of the low revenues, some form of grant, special financing with delayed or lower initial payments, or interest-free capital needs to be acquired. Federal grant dollars are not available. The city or state will have to supply the required monies.

Contracts with the waste supplier (city) and the energy customer need to be completed. Each needs to define responsibilities, guarantees, and all conditions and must cover the 15-yr life of the facility. The city must control the waste to assure delivery to the facility. In addition, they are responsible for providing and operating a landfill site for disposal of the residue and nonprocessible waste. The energy customer must accept a minimum amount of energy and be provided a guaranteed supply of energy. If the energy customer assumes no risk, i.e., does not contribute financing, he should receive no fuel cost savings but rather should pay the full equivalency cost of the energy he receives plus all labor savings he incurs. Contract negotiations should take about 2 months to complete after the site and method of financing have been selected.

The next step is to request quotes on the proposed system by sending out an RFP. A guideline set of specifications and a desired performance package should be sent to all qualified vendors of the incinerators. To prepare the RFP, 1 month should be required; 1 month should be given for the vendors to prepare their reply; and 2 months are needed to review and select the best bid.

The final design of the facility should then be complete. This design incorporates any of the special conditions that were initiated by the selected vendor. This action should take about 1 month and will run concurrently with the next step.

Obtaining funds for construction that was arranged in Step 2 is the next step. Arrangements for the sale of bonds or the commitment of capital dollars should require 2 to 3 months.

The period of construction can take up to 12 months. The site preparation and construction can begin while the incinerators are being manufactured at the factory. The incinerators take 8 to 12 months to build. Assembly of the equipment on site requires about 3 months.

The vendor should be required to start up the system and work out any problems. The operational staff should be on site to receive extensive on-the-job training on running and maintaining the system. This should take a maximum of 3 months to complete if no major problems occur. Steam would be available for sale on an intermittent basis during this time period.

The final portion of the program prior to full operation is the acceptance test. The system must demonstrate capability to meet air emissions regulations and energy output reliability before it is accepted by the owner and the vendor's warranty begins. Testing should not take longer than 3 months, and steam should be available on a regular basis during this time period.

In summary, to complete the program requires 9 steps and up to 42 months. Steam should be available for sale after 36 months. The approval of the State of Montana Legislature, if selected, and the actual construction are the two items that require the longest time frames.

RISK ASSESSMENT

The decision to implement a facility such as this one under consideration exposes the city to various risks. The mere fact that risks are present is not a detriment to the system. Rather, any function or equipment the city purchases does present some risk and management of these risks are an everyday occurrence.

Within the context of this study, SYSTECH has performed a brief assessment of major risks associated with the implementation of this system. The risks are subdivided into two general categories of technical and economic risks. This analysis is not quantitative because of the lack of comprehensive data.

Technical Risks

The major technical risks with this system would be its failure to perform as specified. This risk can be managed in three ways. First, continue to analyze existing and new modular incineration systems until the state government meets in 1983. Through this approach, further data on the operational and maintenance costs can be obtained by monitoring current systems and advances in technology can be observed in units now under construction. This data can be utilized to update and re-evaluate the economic scenarios. The second method for minimizing technological risks is to employ a turnkey procurement approach. By using this procurement method with stringent performance guarantees, there is assurance that the city will take delivery of a working system. The third method of risk reduction is to contract with a third party to operate the facility. The contract should make payments based on performance and make the operator responsible for maintenance.

Economic Risks

Within the assessment of the various risks associated with either proposed facility, one risk outweighs all the rest. That risk is the continued inflation of the costs of natural gas over and above the inflation rate of the costs. If the gas price increases do not exceed all other inflation rates by 5 percent, then there will be very little, if any, revenue generated to retire the debt service at the State Capitol Complex. The revenues at the Fort Harrison site cannot equal the debt service under the optimum scenario so supplemental financing or a grant would be required.

Assuming natural gas prices inflate at 15 percent per year at the State Capitol, the 15-yr revenues would be at best equal to the total costs (O&M plus debt service). (Replacement of equipment costs are included in the maintenance costs.) The risk that the facility would require supplemental financing is, therefore, high.

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